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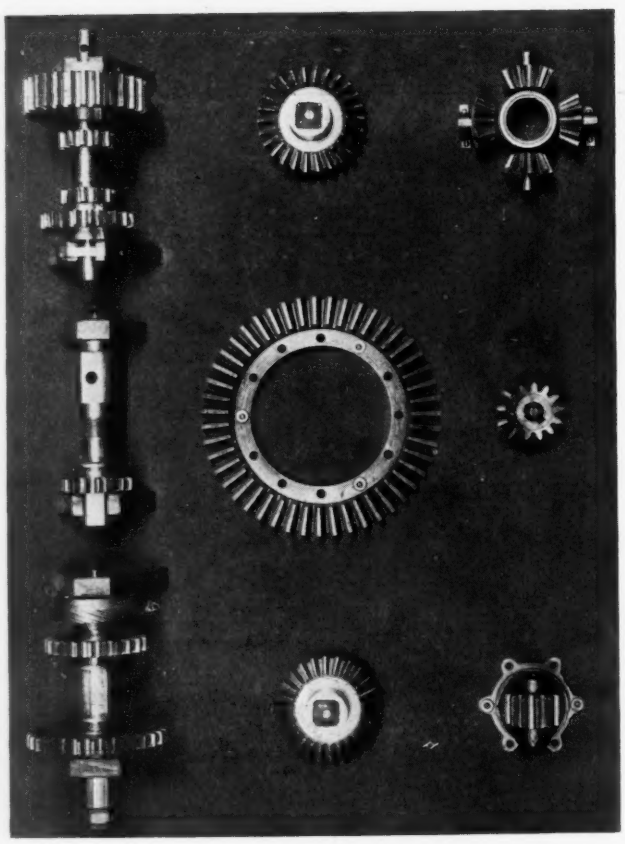

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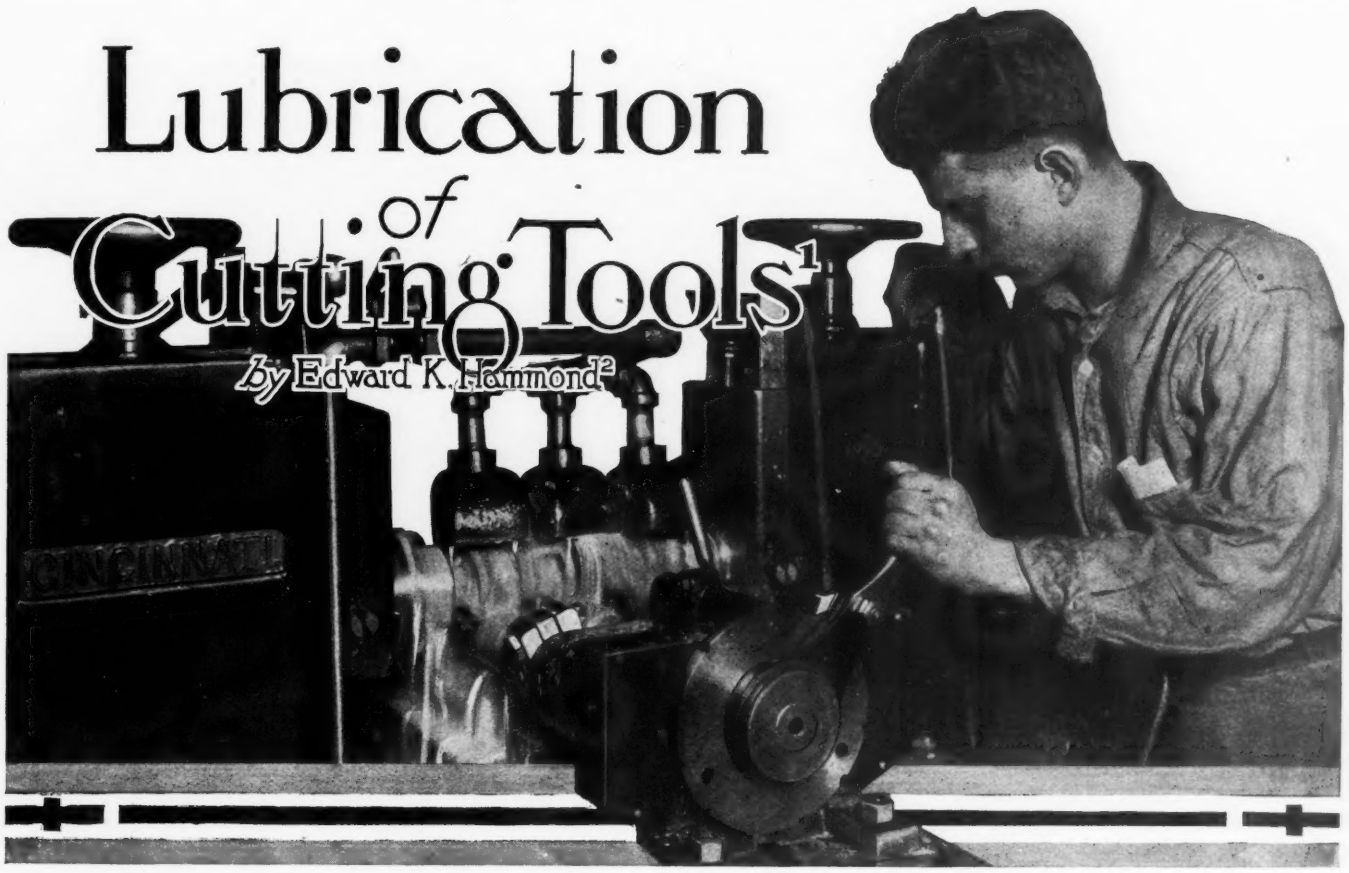
JANUARY MACHINERY 1917

Lubrication of Cutting Tools[1]

By Edward K. Hammond[2]



The characteristics and uses of oils and compounds for cooling and lubricating metal cutting tools will be discussed in a series of articles, of which this is the first. These articles will deal with the theory of lubricating and cooling, methods of distributing, means for applying to the tool and work, methods of collecting after use, recovering oil from chips, methods of filtering and sterilizing, practice in conducting shop and laboratory tests, detailed information concerning oils and compounds used for various machining operations on different metals, specifications for the purchase of oils and compounds, and many other phases of this highly important but heretofore neglected subject.

IN making inquiry concerning current practice in the lubrication of metal cutting tools, it is surprising to find that in many factories where the most modern methods of manufacturing are employed, little exact information is available concerning the theory of tool lubrication. This is doubtless due to the fact that there are so many variable factors that it is hard to separate them and obtain data which would place the subject of tool lubrication on a scientific basis. It must not be inferred from this statement that practice in tool lubrication is generally of a character that produces inefficient results, although this is doubtless true in many cases; but a great number of manufacturers have been content simply to experiment with different oil mixtures and cutting compounds until they have found those which meet the requirements of different classes of work, and then continue their use without having definite assurance that the results secured are the best obtainable, as regards either cost or efficiency.

Functions of Oils and Cutting Compounds

Oil or cutting compound is delivered to a tool in order to increase production, to give longer life to the cutting tool, and in some cases to secure a better finish on the work. The functions of an oil or cutting compound may be presented under five heads: (1) To cool the work and cutter. (2) To wash away chips. (3) To lubricate the bearing formed between the chip and lip of the cutting tool. (4) To enable the cutting tool to produce a good finish. (5) To protect the finished product from rust and corrosion. Each of these functions is quite broad and prevents trouble from a large number of causes.

[1] For other articles published in MACHINERY dealing with the cooling and lubricating of metal cutting tools, see also "Lubricating Systems for Cutting Tools," January and February, 1914; "Graphite Cutting Compound," June, 1910; and "On the Art of Cutting Metals," published serially from January to August, 1907, inclusive.

[2] Associate Editor of MACHINERY.

1. Cooling Tool and Work

The cooling action is the most important function. During the performance of any machining operation generation of heat is due to friction between the tool and work, and to distortion of the chips. This results in raising the temperature of both the cutting tool and the work; and if provision is not made for the removal of this heat, the temperature may become so excessive that the cutting edge of the tool breaks down. This means that there will be a great deal of time lost in stopping machines to change tools and in redressing and regrinding the worn-out tools. Another important consideration is the possibility of having the temperature of the work raised so that it expands considerably during the machining operation, and while the tools may continue to produce parts of the required size when measured at this high temperature, the work will contract on cooling so that it will be under size. It is evident, then, that manufacturers should pay careful attention to the selection of suitable cutting oils and compounds for use in cooling their cutting tools. (The term "lubricant" is commonly applied to a fluid used on metal cutting tools, but as the cooling action of this fluid is by far its most important function, the term "coolant" is more strictly accurate.)

2. Washing Away Chips

In deep-hole drilling, milling and certain other machining operations, ability of the oil or cutting compound to wash away chips is a matter of great importance. For drilling deep holes the tool is ground in such a way that the chips are broken up into short pieces and the fluid is delivered in sufficient volume and under a high enough pressure so that the chips are washed out of the hole. Similarly, in milling and certain other operations there would be a tendency for chips to accumulate around the cutter and retard its action unless the cutting compound provided for washing them away. Unless high pressure is needed to facilitate washing away the chips, the fluid should be delivered at low pressure, as the

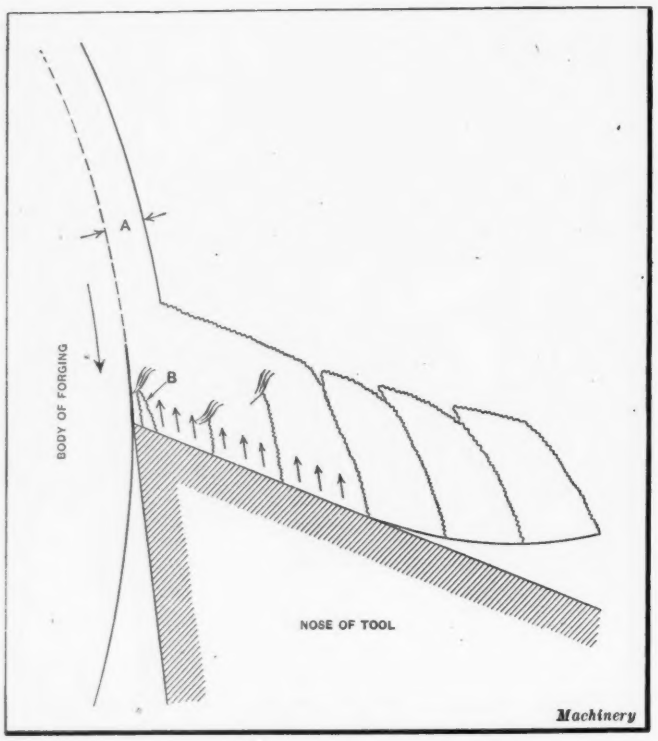


Fig. 1. Conditions under which Chip is removed, showing Possibility of Lubricating Action

results obtained in cooling and lubricating will then be more efficient.

3. Lubrication

The lubricating action is of little importance in machining such materials as cast iron, aluminum, high-carbon steel and some grades of brass, because the chips produced either break up into very small pieces or the material is removed in the form of a powder. As a result, there is little rubbing contact between the chip and tool lip, and so there is not much possibility for improving the operating conditions by the introduction of a lubricant. In such cases, the cooling action is the point of greatest importance. As compared with this condition, lubrication is highly important when machining such materials as low-carbon steel, etc., where long chips are produced that curl back over the lip of the tool. In such cases a bearing is produced in which the frictional resistance is severe, and unless the oil or cutting compound is an efficient lubricant as well as coolant, this friction will result in rapidly wearing out the tool.

The ultimate cause of a tool wearing out is due to dullness produced by rubbing or pressure of the chip upon the lip surface of the tool. The chief element causing this dullness—especially when the tool is running at high speed—is softening of the tool due to heat produced by friction of the chip upon the lip surface. In addition to friction between the chip and lip of the tool, heat developed in cutting is also due to distortion of the chip after it is parted from the work. When machining large pieces, most of the heat is conducted away by the work, but sufficient heat will often be absorbed by the tool to result in its rapid destruction unless a suitable lubricant is applied to reduce friction between the chip and lip of the tool, and to absorb heat developed in cutting. It is generally conceded that there is metallic contact between the cutting edge of a tool and the work, and as friction decreases with increased speed it will be evident that both this frictional resistance and friction between the chip and lip of the tool is reduced by increasing the speed. Hence, if drills and other tools tend to break, it is well to try an increase of speed rather than a reduction of speed, provided that heat developed by the cut is not already excessive. Such a practice results in reducing the load on the tool, and will often be the means of overcoming trouble from broken tools. In many cases the opposite practice is followed, *i. e.*, the speed is reduced, which results in increasing the friction and consequent load on the tool, so that breakage of tools becomes more frequent.

Considerable diversity of opinion exists concerning the possibility of oil affording a lubricating action for the bearing between the lip of a tool and the chip. It is fairly certain that absolute metal-to-metal contact exists between the work and the cutting edge of the tool; but as oils are less efficient cooling mediums than cutting compounds dissolved in water, on account of their lower specific heats, it is assumed that the superiority of oil where long curly chips are produced is due to their lubricating action between chip and tool lip. Granting the accuracy of this premise, it will be of interest to consider briefly the conditions which exist in removing a chip from the work. No better information on this subject is available than that presented by F. W. Taylor in his paper entitled "On the Art of Cutting Metals."

Removal of the chip by a metal cutting tool is due to pressure applied by the lip of the tool and is essentially a shearing action. The conditions are shown in Fig. 1, in which *A* represents the depth of cut or thickness of the layer of metal being cut away. The shearing action causes the metal to part, producing an open space at *B*, and the great pressure applied by the tool lip (indicated by arrows) causes the chip to be distorted in such a way that its thickness becomes approximately twice that indicated at *A*. The portion of the chip running over the lip of the tool acts as a lever which assists in tearing off subsequent sections of the chip. It will be evident that the pressure exerted by the tool is extremely high, in some cases amounting to as much as 100,000 pounds per square inch. Many believe that this high pressure would make it utterly impossible for an oil film to be maintained, as a pressure of approximately 1000 pounds per square inch is regarded as the maximum for journal bearings, etc., in which lubricating oil is used of about the same viscosity as that of oils used on cutting tools.

Probably the true explanation is found in the fact that the tool is kept flooded with oil which is not repelled by heat of the tool, as would be the case with water, and that the chip is continually sliding back over the tool lip. As a result, oil penetrates into space *B* that is produced in tearing the chip

Fig. 2. Use of Brush for applying Oil to Thread Cutting Tool

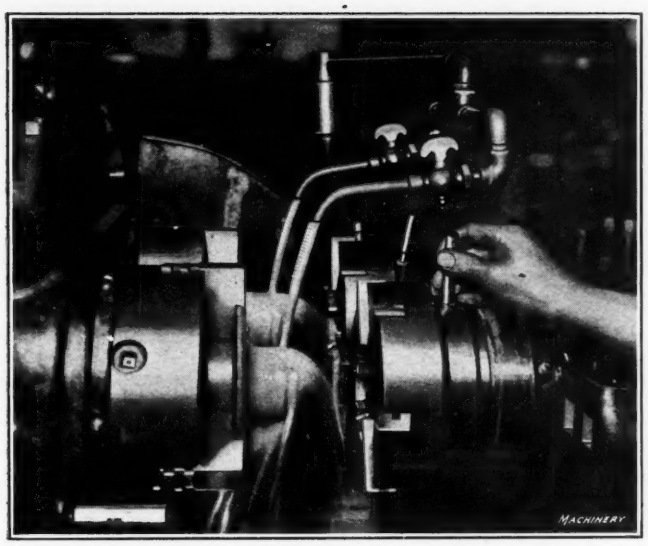


Fig. 3. Method of delivering Lubricant to Threading Dies

from the work and is drawn back into the bearing. Were it not for the continuous supply of oil covering the chip and the constant tendency of the chip to draw oil back with it—an action which is facilitated by the rough surface of the chip—the excessive pressure would doubtless result in destroying the oil film; but under existing conditions it is probable that at least a partial lubrication of this bearing between chip and tool lip is effected. It will be evident from Fig. 1 that the severe pressure and rubbing action on the tool takes place on the lip at a point some distance back from the cutting edge; after tearing off the chip there is a slight amount of metal to the left of space *B* which is cut away by the edge of the tool, and here it seems certain that no lubricating action is obtained, although the oil exerts a beneficial effect by absorbing heat.

4. Securing a Good Finish

There are certain classes of work where an equally good finish will be obtained whether the metal is cut dry or a lubricant is applied to the tool, but when obtaining a good finish for the work is dependent upon the use of an oil or cutting compound, only a small film is actually required at the cutting tool. In most cases, however, the fluid is also depended upon to enable a higher speed, feed and depth of cut to be employed than could be used if the work were machined dry. As a result, it is usually necessary to deliver a far greater volume of fluid to the tool and work than would actually be required so far as considerations of finish are concerned. This is due to several causes, among which may be mentioned necessity of cooling the tools and work, avoiding overheating the oil or cutting compound, and insuring the delivery of a sufficient volume so that there will not be occasional periods of dry cutting.

5. Protection from Rust and Corrosion

As regards protection of the finished product from rust and corrosion, it is well known that good cutting oils will prevent rusting of parts made from iron or steel, but cutting oils containing lard oil with too high a percentage of free fatty acid will cause verdigris to form on brass parts. This is a matter of importance and should receive consideration in drawing up specifications for cutting oils. Mixtures containing vegetable oils do not have this injurious action, but they are likely to give trouble through gumming the bearings of automatic machines; this is particularly marked in oil mixtures containing highly blown rape or cottonseed oil. Cutting compounds made by dissolving soluble oils in water may give trouble by causing iron and steel products to rust, provided the solution is too weak or contains free acid; and poor cutting compounds may also give trouble through gumming.

Historical

In 1883 Fred W. Taylor demonstrated that a heavy stream of water poured directly upon the chip at the point where it is removed from the steel forging would permit of employing a higher cutting speed, thus increasing the rate of production from 30 to 40 per cent. In 1884 a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part, each machine being set in a wrought-iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting) that was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well, whence it was pumped to an overhead tank from which a system of supply pipes led to each machine. Up to that time, so far as the writer knows, the use of water for cooling tools was confined to small cans or tanks from which only a minute stream was allowed to trickle upon the tool and work, more for the purpose of obtaining a "water finish" on the work than with the object of cooling the tool. In spite of the fact that the shops of the Midvale Steel Works (until recently) have been open to the public since 1884, no other shop in this country was similarly fitted up until that of the Bethlehem Steel Co. in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Works.

The use of water or a water solution of soda for the cooling of cutting tools demonstrated that great increases in the rate of production were possible through their application. In many cases, however, the use of either pure water or soda water proved unsatisfactory, and experiments disclosed the fact that delivery of certain grades of oil to the work and tool was the means of securing far better results. It was found that lard oil was one of the most satisfactory mediums for this purpose, and there are still many manufacturers who regard this as the best lubricant for the majority of cutting tools.

The use of lard oil is limited by two important considerations, namely, its high cost and its tendency to gum, causing machine members to stick and pipes to clog. With the view of overcoming these difficulties and of providing a compound which would combine the functions of lubricant and coolant, and would be obtainable at a lower price than pure lard oil, the chemist turned his attention to the possibility of combining mixtures of cheaper oils and water. The first successful cutting compounds of this kind were introduced in about 1900.

Tool Lubricants and Coolants

A great variety of oils and cutting compounds are used for lubricating and cooling metal cutting tools; these may be roughly subdivided into two general classes. The first consists of either pure lard oil, sperm oil, etc.; a mixture of lard oil with certain mineral and vegetable oils; and pure mineral oil or pure vegetable oil. Pure lard oil, a mixture of lard and mineral oil, and pure mineral oil are the most commonly used

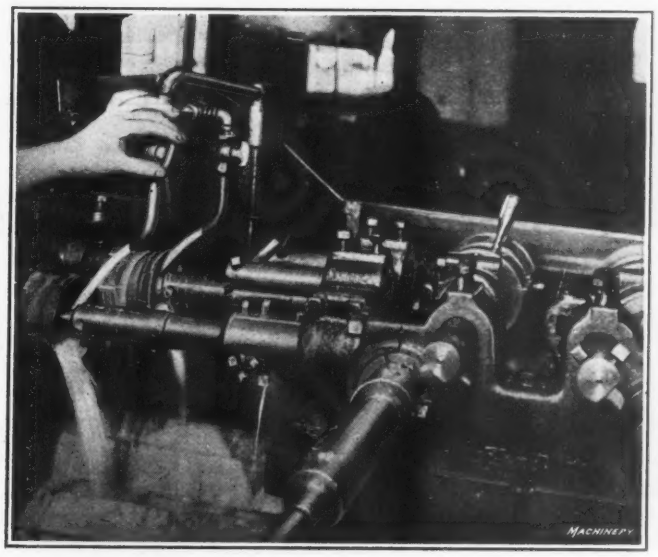


Fig. 4. Same Delivery Tubes as in Fig. 3, adjusted to deflect Flow of Lubricant into Work

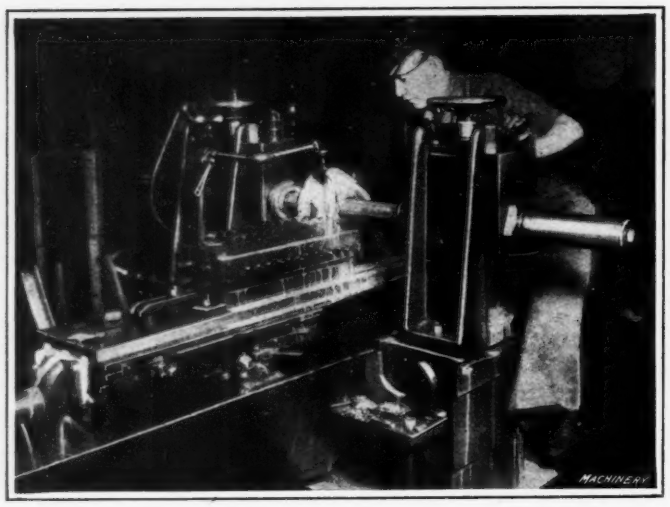


Fig. 5. Delivery of Cutting Compound to Two Cutters on Lincoln Milling Machine where Cutters are close together

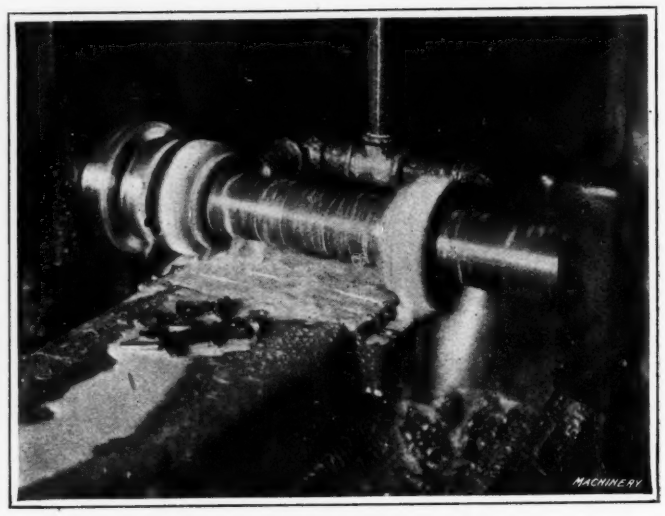


Fig. 6. Another Example of Milling Cutter Lubrication, where Cutters are spaced Some Distance apart

members of this class. The second class consists of the so-called cutting compounds which are water emulsions of soap, oil and other ingredients to prevent the water from causing rust or corrosion and to afford some lubricating action. Originally a saturated water solution of soda was used for this purpose, but this had little more than a cooling effect, and it has now been largely replaced by the so-called soluble oil compounds, which offer a certain degree of lubricating action in addition to their cooling effect. Most of these so-called solutions are really emulsions in which oil is suspended in the water, and to secure this effect the cutting compounds are made up somewhat as follows: Caustic soda or caustic potash is added to an animal oil in order to form soap, which is soluble in water. This soap is then mixed with mineral oil in the desired proportions and the mixture is added to the required volume of water. Made up in this way, the mineral oil is held in suspension in the water in the form of an emulsion, but if an attempt were made to mix mineral oil and water without the addition of soluble soap, the mineral oil would rise to the top, due to its lower specific gravity, and it would be impossible to obtain a uniform mixture. Uniformity of the emulsion is a point of the greatest importance in these cutting compounds, as separation of the oil and water may result in delivering pure water to the tools, thus causing damage by washing oil out of the machine bearings, and by rusting the machine and work.

For all classes of work except that in which the amount of heat generated by the cut is high, thus making the cooling action of the lubricant very important, there is probably no better medium for lubricating and cooling metal cutting tools than pure lard oil. This should be of high quality, however, as poor grades of lard oil contain considerable amounts of free fatty acid, which tends to produce verdigris on brass parts, cause corrosion of other metals, and damage the bearings of machine tools. An excessive amount of free fatty acid will also result in gumming. One well-known manufacturer purchases lard oil under specifications calling for not more than 15 per cent of free fatty acid. The use of lard oil, as previously stated, is limited by its high cost, which is about seventy cents a gallon under normal market conditions, and it was to find a less costly material which led to the introduction of mixtures of lard oil with petroleum oil, and later to the application of pure mineral oil and other inexpensive oils on certain classes of work where such substitutes would give satisfactory results.

Soluble oil compounds dissolved in water represent a step farther in the direction of price reduction, as these solutions can be produced at a low cost—ranging from about 1½ to 16 cents per gallon, according to the degree of dilution—and many firms have gone into the manufacture of these compounds. Their low cost makes cutting compounds especially valuable for use in such industries as bolt and nut manufacture where competition is keen and where the cost of production must be cut down as low as possible. Also for milling, drilling and many other machining operations the soluble compounds give entirely satisfactory results, and their low cost is a strong point in their favor. Attention is called to the fact that to give satisfactory results these compounds must be carefully made from high-grade materials. Otherwise they are likely to give trouble by rusting the work, washing oil out of machine bearings, and gumming slides and other moving parts.

Each manufacturer has his own special formulas for use in making these compounds, but the following is a typical mixture: Caustic soda, 0.65 per cent; alcohol and water, 5.80 per cent; resin acid, 1.64 per cent; fatty acids, 11.76 per cent; mineral oil of 22.5 Baumé specific gravity, 80.15 per cent. This mixture is dissolved in water, the degree of dilution being dependent on the nature of the machining operation and the kind of metal being machined.

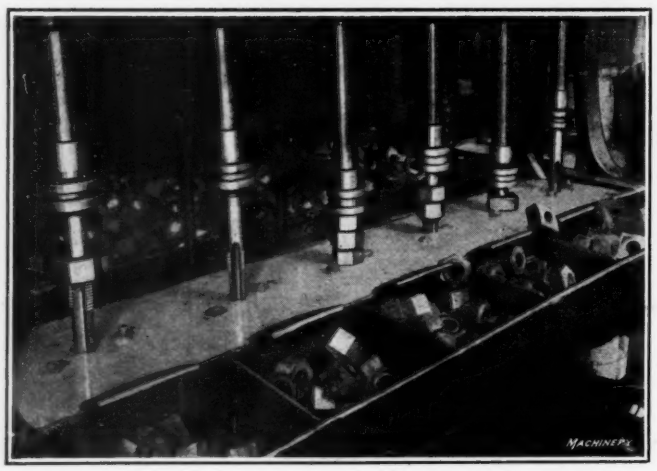


Fig. 7. Nut Taps flooded with Cutting Compound to insure Thorough Cooling

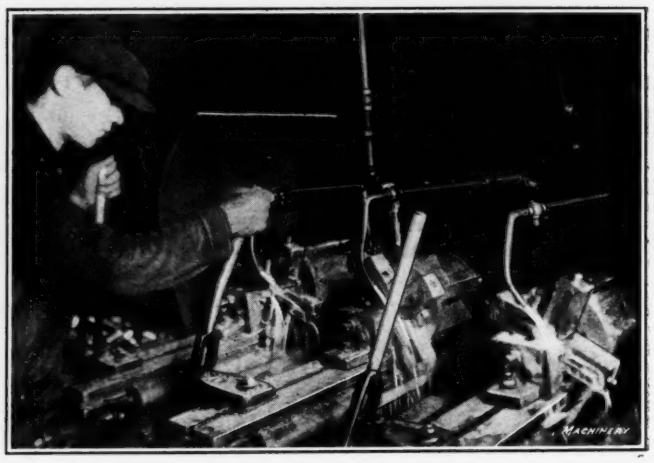


Fig. 8. Multiple Lubricant Pipes with Delivery Tubes arranged to direct Fluid into Tools

Purchase of Cutting Oils and Compounds

There are many machine shops using oils and compounds on metal cutting tools that do not have adequate facilities for testing to determine the purity of cutting compounds and their suitability for handling the work for which they are intended. The best course for proprietors of such shops to follow is to deal with manufacturers of oils and cutting compounds of known reputation. Many different mixtures of oils and numerous cutting compounds appear identical, so that there is always a temptation for a buyer to favor the one that he can secure at the most advantageous price. But the experience of machine shop managers confirms the soundness of making a practice of purchasing a high-grade oil or compound produced in a factory with facilities for testing raw materials and mixing them in such a way as to insure their meeting the purchaser's requirements. Also, such factories have an established reputation that is a particularly valuable business asset in the sale of oils and cutting compounds, and one that they will not be likely to risk losing for the sake of making unfair profits. Complaints are frequently made of unsatisfactory results obtained from mixed oils and cutting compounds sold ready for use. If these were carefully investigated, it would often be found that the trouble was due to one of two causes: either the customer was buying an oil or compound unsuited for his work, or he was making his purchase from an unreliable firm that was selling him an inferior substitute instead of that for which he was paying.

Factors Influencing Selection of Oils and Cutting Compounds

It has been stated that so many variable conditions enter into the cooling and lubricating of cutting tools that it is difficult to secure exact information concerning the action of an oil or compound on the tools. Certain general facts have been established, however, and these form the basis which governs the selection of a suitable lubricant to use in different cases. One of these is the condition under which the machine is operated. A low speed and shallow cut means that little lubricating action is necessary, while a low speed and heavy cut—especially in cases where the material is tough—means that the fluid must possess great lubricating power, and so the use of oil is advisable. Operating at high speed and taking a shallow cut calls for a fluid possessing superior cooling properties, and for this work cutting emulsions are used, due to their high capacity for absorbing heat; if even a low viscosity cutting oil were employed, the friction and heat developed would cause excessive heating of the tools and finished work with troubles from this cause to which reference has already been made. Operating under high speed and heavy cut calls for a fluid with both cooling and lubricating properties. For this purpose a heavily compounded cutting emulsion should be used, because the water solution most effectively dissipates the heat, and by heavily compounding the solution a fairly effective lubricating action is obtained.

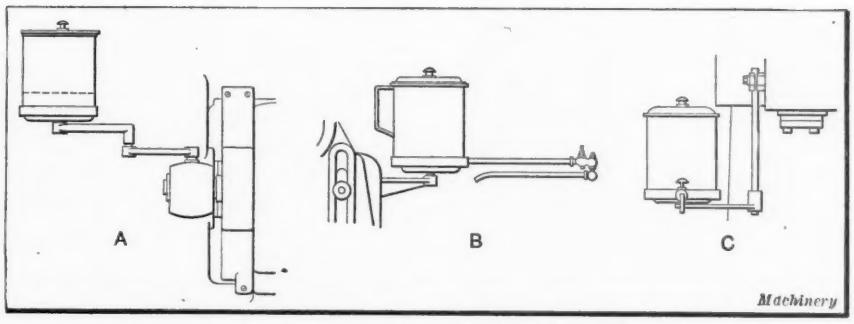


Fig. 9. Three Methods of supporting Drip Cans which afford Adjustment of Position for Delivery Pipe

The effect of the kind of chips produced in cutting different classes of metals upon the requirements of an oil or cutting compound has been briefly referred to, and in addition it may be mentioned that the selection will be governed to some extent by the hardness of the metal. The selection will also be affected by the character of the machine, as well as the conditions of speed and the depth of cut under which it is operated.

Methods of Applying Lubricant to Tools

There are a variety of methods of delivering lubricant to cutting tools, and each has its particular field of application. These methods run all the way from the use of a squirt can or brush, with which lubricant is applied to the tool, up to a central distributing station equipped with pumps for delivering oil through pipe lines to all the machines in the factory, a system of piping for returning the lubricant, and filters and sterilizers for purifying the returned oil. The squirt can and brush are still used in certain cases for lubricating small taps, end mills, threading tools, etc., and for this purpose give fairly satisfactory results. The next step in the development of methods of supplying lubricant consists of a small drip can, mounted on the machine, from which oil or cutting compound is allowed to trickle by gravity to the tool and work. These cans are usually provided with a wire gauze strainer to remove chips and suspended impurities from the lubricant. After flowing over the work, the lubricant is caught in a second can, suspended under the machine, and from time to time its contents are poured back into the drip can ready for subsequent use. Various methods are used for suspending drip cans on machines in order to provide adjustment for delivering the fluid to the required position, and Fig. 9 shows three typical examples. At *A* it will be seen that the can is mounted on a jointed bracket, which can be swung on its pivots in order to bring the can and delivery pipe into the desired position. The can shown at *B* is carried by a fixed bracket, but the delivery pipe is jointed to afford adjustment. At *C* the can is suspended on a bracket held by a vertical rod in a split clamp, providing both vertical and horizontal adjustment of position. Methods of this kind for supplying lubricant are still used in factories where the tools work under such conditions that the coolant or lubricant does not need to be delivered in a large volume. Their only claim to favor is that they are inexpensive.

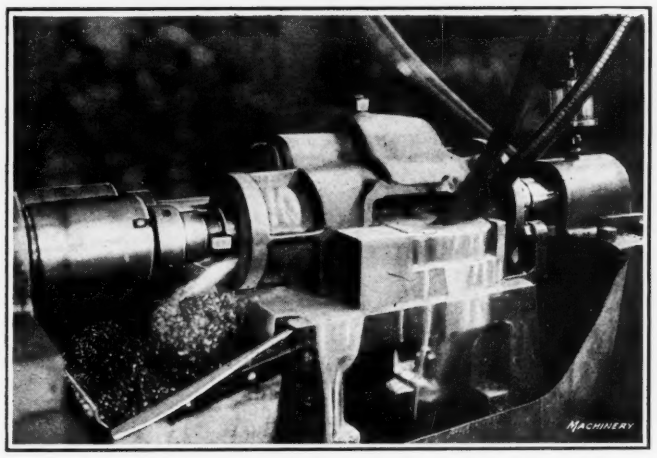


Fig. 10. Flexible Tubes for delivering Lubricant to Work

Fig. 11. Lubrication of a Facing Tool

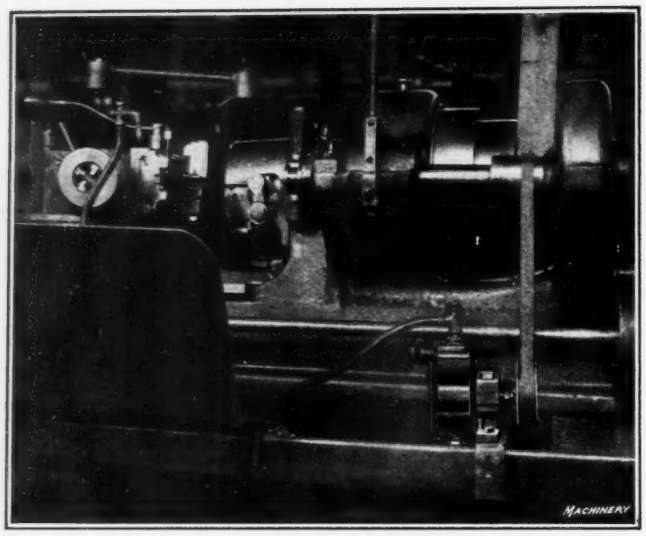


Fig. 12. Geared Pump in Use, showing Method of mounting, driving and delivering Lubricant to Work

Provision of Individual Pumps on Machines

When a considerable volume of oil or cutting compound is required for the work, the drip can is unsatisfactory, due to the necessity of frequently emptying the can; and this led to the development of individual pumps for use on machine tools. Four typical classes of pumps are used for this purpose, and these are (named in the order in which they are most generally applied) the geared, wing, plunger and centrifugal types. Each of these will be described in detail under individual headings. In all cases, too much emphasis cannot be laid upon the necessity of having the pump and delivery pipe of ample capacity to supply a copious flow of lubricant to the tools and work. The average size of delivery pipes on machine tools runs from ¼ to ⅜ inch, but the latter should be made the minimum and means provided to regulate the volume of lubricant delivered by the pump according to the requirements of the work. Many cases of failure to secure satisfactory results are due to the inability of the pipe to deliver the required volume of lubricant at low pressure, rather than to the unsuitability of the lubricant. A large delivery pipe provides for the delivery of a copious flow of lubricant at low pressure, which is the ideal condition, as regards both the cooling and lubricating

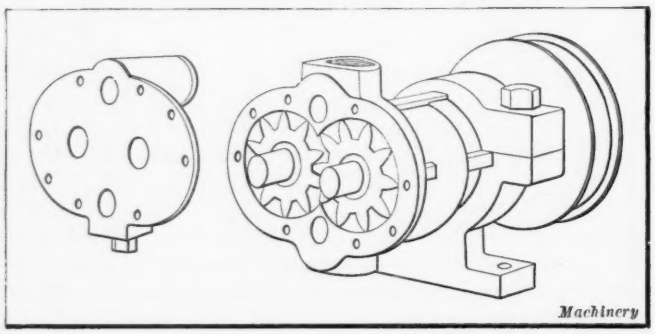


Fig. 13. Geared Pump made by Goulds Mfg. Co., showing Arrangement of Gears

action of the fluid. In addition to the importance of keeping down the temperature of lubricants so that they may exert the desired cooling action, low temperature is of great importance from the standpoint of pump efficiency. If the temperature is allowed to rise to such a degree that vapor is given off from the lubricant, it is likely to interrupt the pump suction. In order to be sure of efficient operation of pumps it is also necessary to keep the inlet to the suction pipe well below the surface of the reservoir. This is also a matter of importance due to the fact that drawing air into the pipe may cause oxidation of the oil which produces a sludge that will tend to clog the pipes and give trouble in other ways.

The Geared Pump

The commonest form of lubricant pump used on machine tools equipped with a tank and pump, consists of the rotary geared pump which is so well known that it requires little description. The pumps can be made to deliver lubricant when running in either direction, thus adapting them for use on machines where reversal is required to back off threading dies, etc.

Several methods are used for driving geared pumps, the most common of which is by a belt from the countershaft or a pulley on the machine, or by direct-connected gearing. The claims made for the geared type of pump are that it affords a positive pressure without fluctuation in the rate of delivery. In pumps of this type made by C. F. Roper & Co., Hopedale, Mass., and by other firms, provision is made against loss of prime so that any liquid from water up to the heavier oils may be easily pumped without the necessity of priming the pump. The compact form of these pumps is a point in their favor.

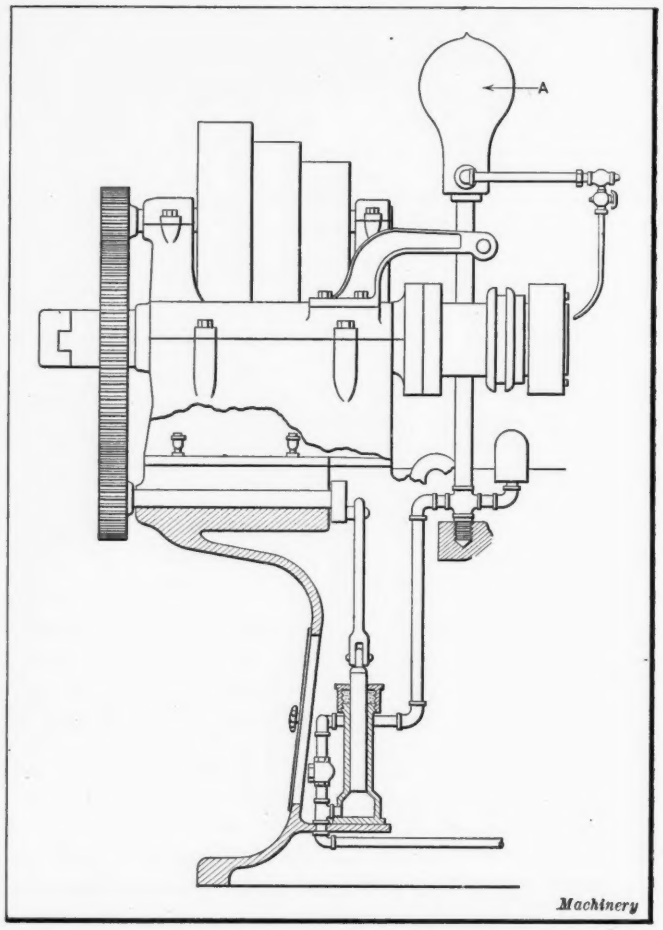


Fig. 14. Use of Plunger Pump on Bolt Threader made by National Machinery Co.

One of the geared pumps is illustrated in use in Fig. 12; and Fig. 13 shows the mechanism of this pump. Reference to the latter illustration shows that the lubricant drawn through the suction pipe is carried around in the spaces between the gear teeth and the pump chamber. This lubricant is forced out through the discharge pipe to the tools on the machine. To obtain the best results, the pump should be placed as near as possible to the level of the lubricant in the tank. This type of pump is capable of working with a suction lift of from three to four feet without priming, and will develop considerable pressure when this is necessary for washing away chips. A by-pass is provided in the pump to enable the operator to

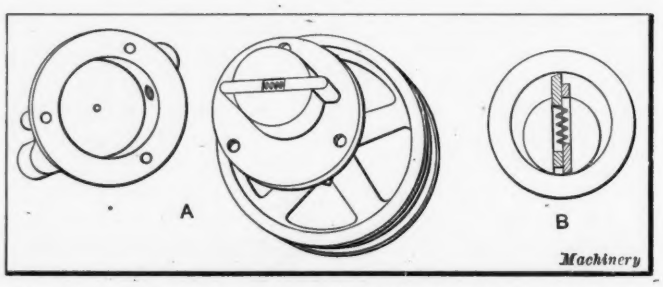


Fig. 15. Two Styles of Wing Pumps; at B is shown Means of obtaining Pressure Relief

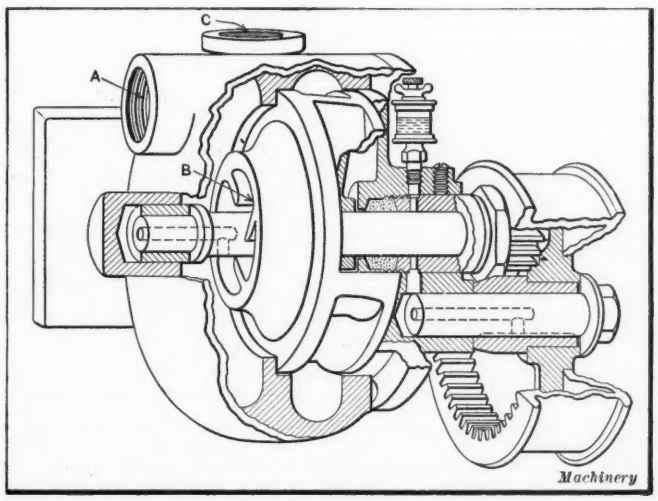


Fig. 16. "Fulflo" Centrifugal Pump made by Cincinnati Lubricant Pump Co.

regulate the volume of fluid delivered. To give an idea of the capacity of these pumps it may be mentioned that the Goulds Mfg. Co., Seneca Falls, N. Y., builds geared pumps in two sizes which are known as Nos. 1 and 2. Operating at speeds of from 200 to 500 revolutions per minute, the No. 1 pump has a capacity for one and one-half to four gallons per minute, working through suction and discharge pipes ½ inch in size; under the same conditions of speed the No. 2 pump has a capacity for delivering from four to ten gallons per minute when working through ¾-inch suction and discharge pipes.

Wing Type of Pump

Fig. 15 shows two examples of the wing type of pump which is used extensively on machine tools. This pump consists of a revolving stem which is set eccentric to the bore of the pump

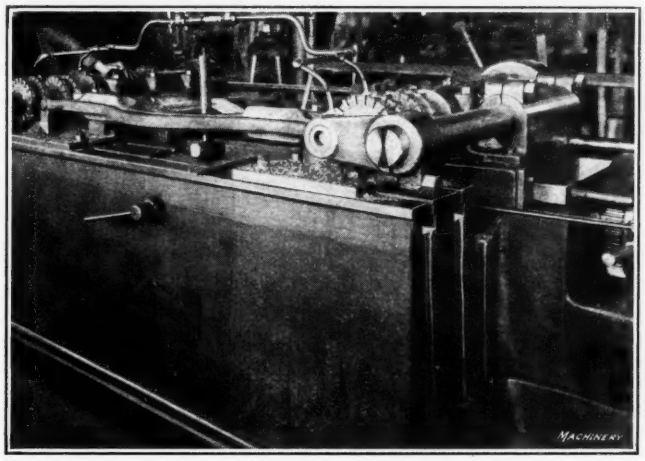


Fig. 17. Arrangement of Pipes to deliver Cutting Compound to Two Gangs of Milling Cutters

chamber, thus leaving a space at one side which contains the fluid being pumped. This type of pump delivers a large volume of oil when running at about 100 revolutions per minute, and on account of this low speed it requires very little attention. It will be seen that the revolving stem is slotted to receive a pair of flat plates or wings which are forced apart by springs. As the stem rotates, the ends of these wings remain in contact with the inside of the pump chamber, thus drawing fluid in and discharging it in one direction or the other according to the direction in which the stem rotates; this makes the wing type of pump suitable for delivering lubricant to tools on automatic screw machines, etc., where reversal of direction of rotation is often necessary. Pumps of this type will develop sufficient suction to lift fluid a slight distance, but it is better practice to have the pump submerged in order to avoid the necessity of priming. In the type of pump shown at *B* in Fig. 15, it will be noted that the wings are tapered at the ends so that when a full discharge is not required, pressure of the liquid will force the wings back, thus making a relief or overflow valve unnecessary. The simplicity of all parts of wing pumps enables them to run for a long time without getting out of order. The same methods are employed in driving these pumps as in driving geared pumps.

Reciprocating or Plunger Type of Pump

Fig. 14 illustrates the use of a plunger pump for circulating oil or cutting compound on a bolt cutting machine made by the National Machinery Co. of Tiffin, Ohio. Pumps of this kind are used in various sizes and with different numbers of cylinders according to the volume of cutting compound to be delivered. In the case illustrated the pump has an adjustable stroke to provide for varying the volume of lubricant delivered

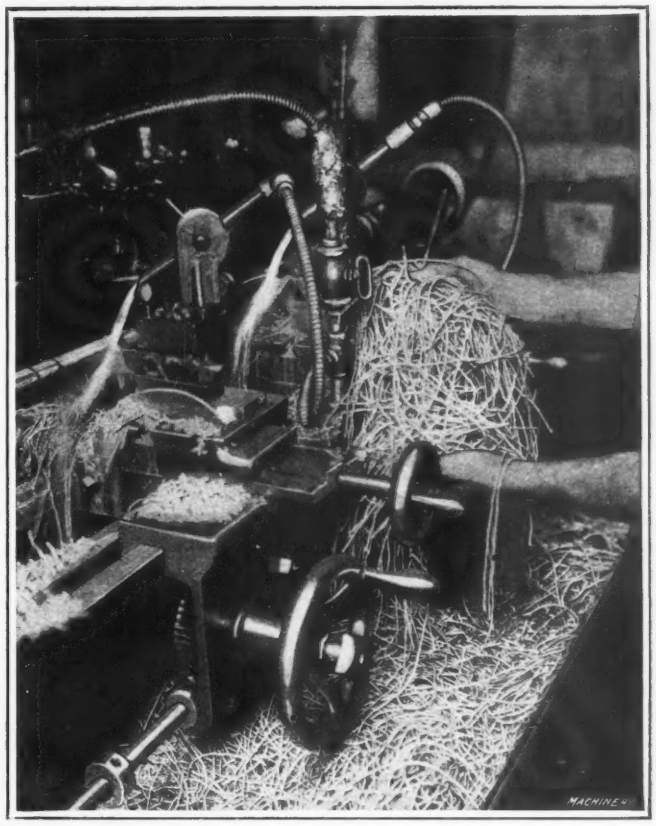


Fig. 18. Delivery of Cutting Lubricant on Lathe with Two Turning Tools

to the tools, and a safety overflow valve relieves back pressure in case the valve on the spout is closed while the machine is in motion. To avoid "pulsations" which would otherwise result from the use of plunger pumps, it is good practice to insert an air bell *A* in the delivery line which forms a cushion that takes up inequalities in pressure. In the case of multiple plunger pumps the cranks are equally spaced around the crank circle so that the variations of pressure in the cylinders tend to compensate for each other. This condition is shown diagrammatically in connection with the description of plunger pumps for central distributing stations.

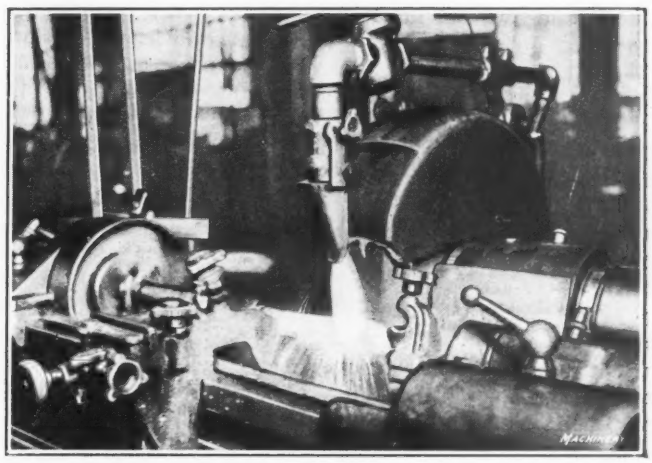


Fig. 19. Adjustable Deflector for delivering Coolant to Grinding Wheel and Work

In the plant of the Crucible Steel Co. of America at Harrison, N. J., triplex plunger pumps, 4 by 6 inches in size, with capacities for displacing forty gallons of oil per minute, are used for the lubrication of tools on shell boring lathes. One pump is used for two machines, the pump and lubricant supply being contained in a pit in the concrete into which the lubricant is returned after being strained.

Centrifugal Type of Pump

As the name implies, the operation of centrifugal pumps is based on the action of centrifugal force. They are provided with an impeller which consists of a wheel having passages into which fluid is drawn from the suction pipe, carried around inside the pump case and expelled into the discharge pipe through the action of centrifugal force. An important point in their favor is that these pumps are capable of delivering a large volume of fluid at low pressure.

The Cincinnati Lubricant Pump Co., Cincinnati, Ohio, makes a small centrifugal pump, shown in Fig. 16, for delivering oil or cutting compound to tools where an individual distributing system is used on each machine. The important features of this pump are that at no point is the channel through which lubricant passes smaller than the ¾-inch suction and delivery pipes, and hence there is practically no chance for the pump to become clogged. Small chips and grit carried by the fluid will not damage this pump, and there are no parts that are likely to get out of order. Also, the design is such that the pump cannot lose its prime, as both inlet and outlet are above the pump level and there is always enough fluid in the pump to start it. Lubricant is drawn in through suction pipe *A* and finds its way into the impeller through spaces *B* around the bearing; then the impeller expels the fluid into the delivery pipe *C*. To regulate the flow it is merely necessary to open or close a stop-cock at the outlet; with this exception there is no valve in the pump or piping. The operator does not need to leave his work to regulate the flow of coolant. The following gives the capacity in gallons per minute for different pump pulley speeds when operating under a suction lift of 12 inches and a head lift of 4 feet, which is about the maximum requirement for machine tool installations: 300 R.P.M., five gallons; 350 R.P.M., ten gallons; 400 R.P.M., fifteen gallons; 450 R.P.M., eighteen gallons. To obtain a greater volume for these suction and head lifts or the same volume for increased lifts, it is simply necessary to increase the pump pulley speed.

When the design does not prevent loss of prime, it is good practice to have the pump submerged in the reservoir to avoid the necessity of priming. On grinding machines where this practice is followed, running bearings should be protected from gritty water. On milling machines built by the Cincinnati Milling Machine Co., where flooded lubrication is required, centrifugal pumps are used that are capable of delivering eleven gallons of cutting compound when running at 1150 revolutions per minute. This washes away the chips.

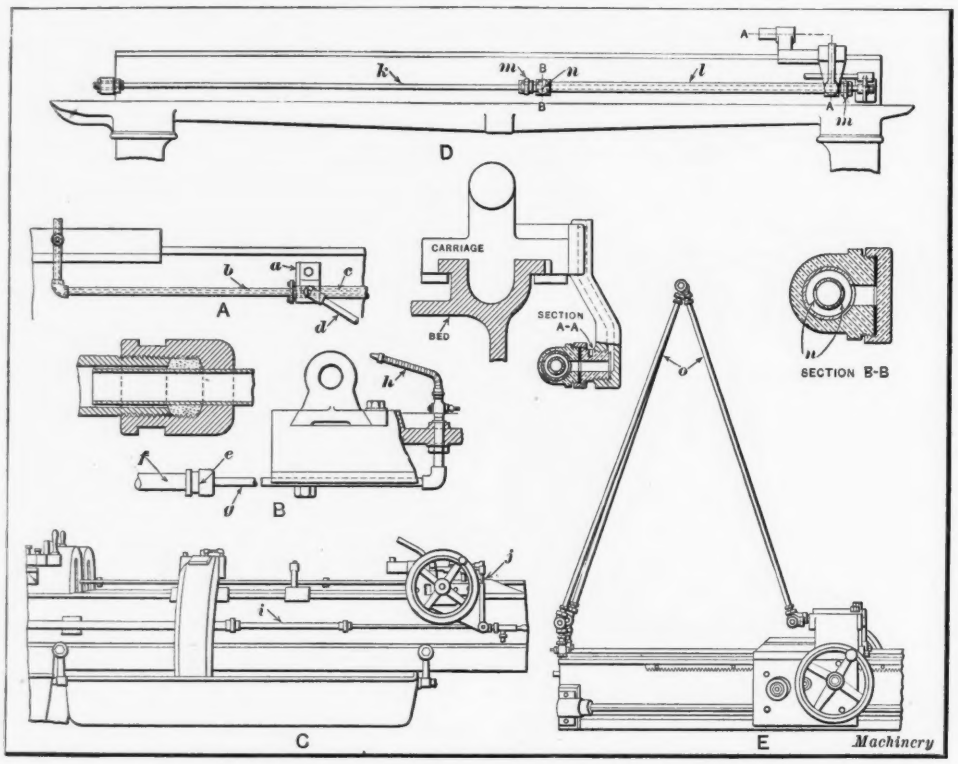


Fig. 20. Methods of delivering Lubricant to Tools where Compensation is required for Movement of Machine Members

Delivery of Lubricant to Tools on Moving Carriages

Provision of piping to deliver lubricant from the pump to the cutting tool is most easily taken care of in those cases where no adjustment is required to take care of feed movements, etc. It frequently happens, however, that the tool carriage has to be traversed through a considerable distance, which necessitates special means for delivering the lubricant to the work. One of the simplest methods of handling this problem is to use a flexible metal tube to connect the moving carriage and the supply pipe on the machine, and this gives very satisfactory results, except that when the tube is very long and in an exposed position, it is likely to get in the operator's way.

In many cases use may be made of telescopic tubes which furnish the necessary compensation for the movement of the tool carriage. Two such arrangements are shown at *A* and *B* in Fig. 20. A partial view of the back of a turret lathe is illustrated at *A*, on which there is a fixed bracket *a* provided with a stuffing-box through which pipe *b* slides as the saddle moves on the bed of the machine. Pipe *b*, which delivers oil to the cutting tools, projects back into pipe *c* which is of somewhat larger diameter, and oil is delivered into this pipe through tube *d* which makes connection with the pump. At *B* is illustrated the method of compensation provided on the oil delivery system for the reciprocating carriage of a gear-cutting machine. In this case use is also made of two telescopic tubes connected by a stuffing-box *e*, of which an enlarged view is shown. Oil is delivered from the pump through the pipe *f* and thence through small pipe *g* to flexible tube *h* on the carriage.

In the case of the rifle barrel drilling machine illustrated at *C*, considerable compensation is required because the feed motion of the carriage is through a distance somewhat greater than thirty inches. This compensation is furnished by telescopic tubes *i* from which connection is made by pipe *j* to the hollow barrel drill, through which oil is delivered to the cutting point. In order to be effective in washing chips out of the hole, oil must be delivered to the barrel drills at a pressure of about 800 pounds per square inch. In some cases this pressure causes trouble by throwing the carriage back with great violence when the half-nuts on the lead-screw are released to return the carriage while there is still pressure in tube *i*. The machines are equipped with a spring at the end of the machine bed to absorb shock when the carriage is accidentally thrown back in this way, but in many cases the effect of the spring is insufficient to give the desired result.

To overcome this difficulty a rather ingenious method was developed, as shown at *D*. Instead of using telescopic tubes oil is delivered through a small tube *k* connected with the oil supply at the left-hand end of the machine; this tube runs the entire length of the bed and is capped at the right-hand end. Sliding over tube *k* is a larger tube *l* with a stuffing-box

m at each end and a connection at each end to provide for passing oil to the tube supported in the machine carriage. Oil escapes through a hole *n* in inner tube *k* into outer tube *l* and thence to the carriage; and it will be evident that the pressure inside the larger tube is balanced in all directions so that there is no danger of the carriage being thrown back through pressure remaining in the tube when the half-nuts are released from the lead-screw. As shown at *D*, the left-hand carriage connection is capped and the carriage is connected to the right-hand end of tube *l* to adapt the machine for drilling long barrels; for drilling short work with short drills the carriage would be connected to the left-hand end of tube *l*.

A substitute for the telescopic tube arrangement shown at *C* is illustrated at *E*, which will be seen to consist of two jointed tubes *o* leading to the carriages of a duplex rifle barrel drilling machine. As the carriages are fed forward the middle joints of these hinged tubes drop toward the bed of the machine, thus providing the necessary movement of the carriage without interfering with the oil supply.

Nozzles and Distributing Devices

The efficiency of the results obtained in cooling and lubricating cutting tools is largely governed by the form and size of nozzle through which the lubricant is delivered, the direction and position in which it is applied, the pressure at which it is delivered, and the volume of lubricant applied to the tool and work. If one or more of these factors is defective, it may be the cause of unsatisfactory results. The size of the lubricant delivery nozzle is important because this governs the volume delivered at a given pressure, and the form of nozzle is responsible to a large extent for the manner in which the lubricant is distributed over the tool and work. In all cases the aim should be to deliver the lubricant in such a way that it will keep a constant supply at all points on which the tools are working, and this volume should be ample to provide for cooling the tools and work and prevent the lubricant from becoming too warm.

Proper Direction in Which to Deliver Fluid

In early experiments conducted by F. W. Taylor in the use of a stream of water for cooling cutting tools, the first plan adopted was to deliver a stream of water up between the clearance flank of the tool and the work so that the water would almost reach the cutting edge of the tool at the point where the greatest cooling action is required. Mr. Taylor was so confident of the soundness of this theory that he did not at first deem it worth while to experiment with throwing streams of water in any other way, but some months later he tried the plan of throwing a stream of water upon the chip directly at the point where it is removed from the work, and found that a material increase in cutting speed could be employed under these conditions. In applying water in this way for cooling tools used in the performance of manufacturing operations, Mr. Taylor found that when a sufficiently heavy stream of water was thrown upon the work to give the desired cooling action, it had a tendency to splash more than when thrown upon the forging just above the chip, and to avoid discomfort mechanics would change the position of the delivery pipes unless care was taken to prevent this practice. Mr. Taylor was the first to find that the most satisfactory results were obtained by delivering a large volume of water at low pressure to exactly the required position, because water delivered in this way will cover a large area and will not tend to rebound from the work, thus exerting its maximum effect as a coolant.

The direction in which the fluid is applied should always be selected with the view of obtaining a location where it will remain on the work long enough to have the maximum effect, that is to say, where there will not be a great tendency to throw the lubricant; and this is particularly desirable in the case of high-speed machinery such as grinding machines, because the fluid may actually be thrown clear of the work, onto the operator and the floor surrounding the machine. In this connection the pressure at which the fluid is applied is also very important; if the pressure is too high there will be a tendency for the fluid to rebound upon striking the work, so that it will not have the maximum effect in cooling and lubricating. If, on the other hand, the pressure is low, the fluid is enabled to remain on the work, thus absorbing heat and lubricating the bearing between the chip and lip of the tool. The best practice in tool lubrication calls for the delivery of a large volume of fluid at low pressure, and as oils and cutting compounds are now being purified so that they can be used continuously, this use of a large volume of even high-priced oil involves only a moderate increase in investment in oil upon which the overhead charge is not likely to be excessive.

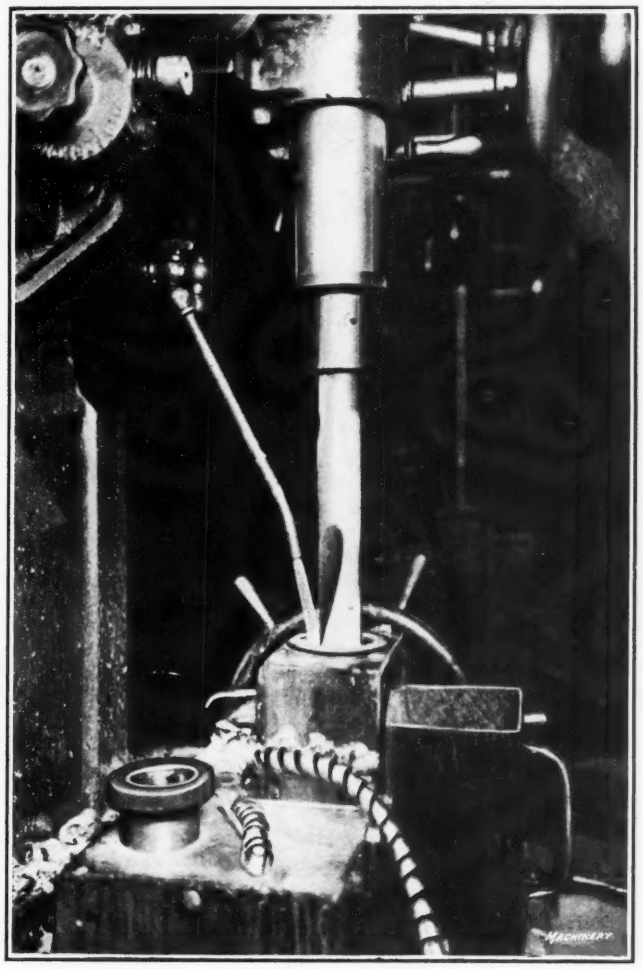


Fig. 21. Delivery of Coolant to a Large Twist Drill

Forms of Nozzles and Distributing Devices

In delivering lubricant to the tools it is obviously important to apply it at exactly the points where cooling and lubrication are required, and for this purpose many different forms of delivery tubes and nozzles are employed. Typical examples of such devices are illustrated in Figs. 22 and 23. For single-point cutting tools, narrow milling cutters, drills, etc., a pipe with a single outlet is all that is necessary, but two or more outlets are required for gangs of cutters and multiple tools unless a wide spout is used. The simplest arrangement available is a plain pipe with an open end. In most cases, however, it is necessary to provide adjustment for locating the nozzle in the desired position relative to the work. At *A* it will be seen that the pipe is hinged to provide for swinging the nozzle into place over the work. Another good example of this kind is illustrated at *B*, which consists of a small faucet supported by a rod clamped in such a way that both vertical and horizontal adjustment are obtained. Connection between the faucet and supply pipe is made by a flexible tube. A similar example is shown at *C* in which the faucet is supported by a clamp carried by a rod screwed into a tapped hole in a machine boss or similar member. The delivery pipe shown at *D* is provided with what might properly be called universal adjustment, as the first section of pipe has a ball and socket joint which enables it to be swung in practically any direction, while the second section of pipe slides in and out to give the desired length. An arrangement for delivering lubricant to a bolt threading die is shown at *E*, where it will be seen that the vertical nozzle may be swung around the

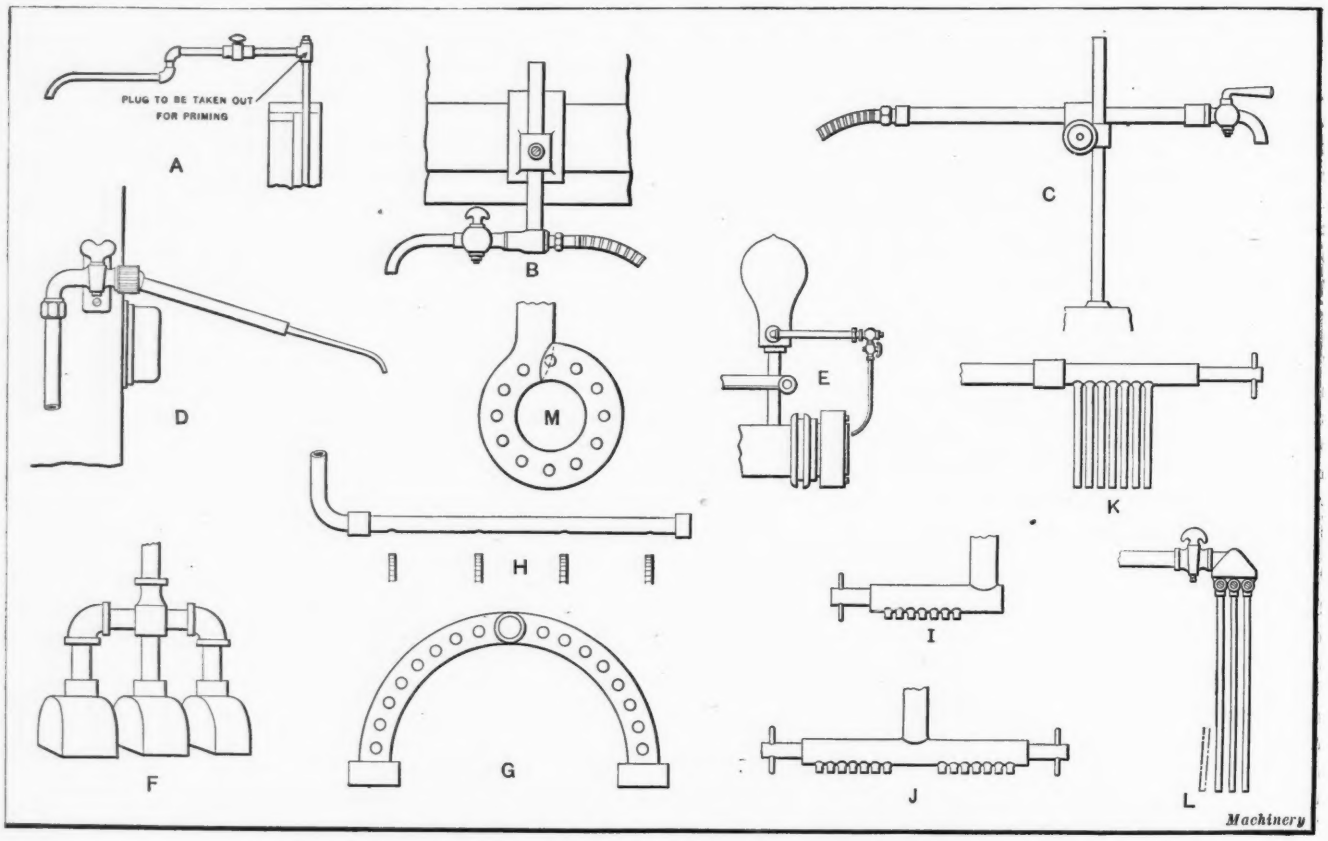


Fig. 22. Miscellaneous Examples of Nozzles and Delivery Tubes for supplying Lubricant to Tools

horizontal delivery pipe to obtain the desired radial position, and this nozzle is bent to direct the flow of lubricant into the die. The supply is delivered by a plunger pump and the air bell provides for absorbing the effect of pulsations and obtaining a uniform pressure.

In the performance of heavy milling operations, flooded lubrication of the cutters is highly important. In milling, the chips are usually short, and so friction between the cutter teeth and chips is not likely to be very great. In such cases the fluid acts as a coolant rather than a lubricant; and to keep the fluid on the work use is made of shields at the end of the delivery pipe which drop down over the cutters in such a way that any fluid which is thrown up is caught by these shields and drops back onto the tool and work. An example of this form of delivery pipe and shield is shown at *F*. In another section of this article reference will be made to the use of compressed air for cooling work and tools. In order to distribute the air over the cutter so that it may exert the maximum cooling action, the delivery pipe is constructed as shown at *G*. At each side of the cutter there is a pipe bent to the same curvature as the cutter. A series of holes is drilled in the pipe corresponding to the spacing of the cutter teeth so that air flows onto the tool and prevents the steel from becoming overheated. Another device for delivering fluid to milling cutters is shown at *H*, which consists of a horizontal pipe with holes drilled in it to correspond to locations of a gang of four milling cutters. Such an arrangement proves satisfactory provided the pipe and holes are of ample size to deliver the required volume of fluid.

For delivering lubricant to multiple turning tools such as those used on the Fitchburg "Lo-swing" lathe, and similar cases where it is required to obtain considerable distribution of the fluid, delivery tubes of the form shown at *I*, *J* and *K* may be advantageously employed. It will be seen that these consist of horizontal pipes to which delivery nozzles are connected, and the spacing and length of these nozzles may be varied according to the requirements. In handling different classes of work, there will be different numbers of tools in use, and in order to adapt these delivery pipes to the requirements of various cases, sliding plugs are provided in one or both ends, which may be moved to shut off the supply of lubricant to those nozzles which are not required. A somewhat similar arrangement is shown at *L* except that in this case the delivery tubes are pivoted in order that the adjustment of each tube may be regulated according to the position in which it is required to apply the lubricant. At *M* is shown a good method of delivering lubricant to drills, end-mills and similar tools that are doing heavy work. The ring pipe surrounds the tool and delivers the fluid in a practically continuous circle, through holes which are inclined inward toward the tool. A device is shown at *N* which was developed for use in delivering fluid to hacksaw blades and other similar tools. It will be seen that this consists of a pipe with a cap at one end and a valve at the other which provides for turning on or off the entire supply of fluid. Holes drilled along the pipe allow the lubricant to escape onto a sheet-metal plate *a* over which it flows to the saw and work. This device was especially developed for delivering lubricant to hacksaw blades and is placed in such a position that plate *a* comes up against the side of the blade, thus distributing the lubricant uniformly.

At *O* is shown a method of delivering oil or cutting compound to several tools. This will be seen to consist of an inner tube connected to the supply pipe with an outer tube which is a sliding fit over it. The bearing between the inner and outer tubes is a close fit in order to be leak-proof. Drilled in both tubes is a series of unequally spaced holes located in such a way that when the outer tube is slid along, different numbers of holes in the inner and outer tubes will come into coincidence in order to allow for the escape of oil or cutting compound at these points. For instance, in the position shown there are three openings, but if the outer tube were moved to the right through a distance equal to one space between holes, it would result in providing four openings. Pipes of this kind may be made with different spacing of holes for delivering lubricant to different combinations of tools.

The delivery pipe shown at *P* is adapted for supplying cutting compound to multiple tools, and is a substitute for the one shown at *O*. In the present case it will be seen that a single capped pipe is used in which a series of holes has been drilled and tapped. Screws are furnished to plug up these holes and the necessary number of screws can be removed in those positions where it is required to deliver cutting compound to the tools. Still another method of securing the same result is shown at *Q*; in this case holes are also drilled in the pipe, but spring clips made of sheet steel surround the pipe, and by twisting the clips around so that the opening

between the ends of the clip exposes the necessary number of holes the cutting compound can be delivered to a number of tools.

At *R* is shown a somewhat similar idea for the lubrication of gangs of tools and for use in cases where it is desired to deliver lubricant over a considerable area. A delivery tube of this form would be used for supplying fluid to multiple turning tools and similar cases. It will be seen that each outlet is provided with a small cock which can be turned on and off according to the positions at which it is desired to deliver fluid. At *S* and *T* are shown two methods of delivering lubricant to tools on screw machines and turret lathes. The method shown at *S* will be seen to consist of a double supply pipe, one branch leading to the center of the turret for carrying lubricant direct to the points of oil-tube tools, and the other delivering lubricant to other kinds of tools held in the turret. A somewhat similar arrangement is shown at *T*, where it will be seen that the first branch of the pipe delivers oil into a funnel which communicates with the center of the turret to supply oil-tube tools, while a branch pipe carries lubricant to forming tools, etc.

In handling automatic screw machine work where there are a number of tools working at the same time, the problem of delivering oil is somewhat more difficult, as it is required to supply the proper amount of oil to all tools and still prevent delivering it at intermediate points where no tools are in operation. The latter consideration makes it impractical to use a pipe with a long orifice which extends across the full length of the piece on which the tools are working. A typical example is shown at *U*, and this also illustrates a satisfactory device. Suppose we have a piece of work of the form shown on which the small diameter is being turned down by a box-tool, while a forming tool is at work on the left-hand end of the piece. It is required to deliver oil to both the box-tool and forming tool, but if oil is also delivered on the intermediate diameter on which no work is being done it will result in a reduction of the supply of oil available at those points where lubricant is required. A simple and efficient method of overcoming the difficulty is to have a horizontal pipe with holes drilled in it through which oil can flow onto the forming tool and box-tool, but with no holes drilled in the intermediate space where the bar is not being machined. This idea is capable of extension to cover a great variety of cases.

In delivering lubricant to a milling cutter of considerable width or to a hob it is necessary to distribute the fluid over the entire width of the tool, and in cases of this kind use may be made of the forms of nozzles shown at *V* and *W*, both of which provide for distributing the fluid over a considerable area. It will be seen that nozzle *V* is of the so-called "closed" type and this is used in a vertical position; nozzle *W* is open at one side and is usually employed where the delivery pipe comes to the cutter in a horizontal or slightly inclined position. Where desired, both of these types of nozzles may be supported on a clamp and the end of the regular delivery pipe dropped into them in order to avoid changing the standard form of pipe, which is required on the machine for handling many classes of work.

Probably there is no device for delivering lubricant to cutting tools which is capable of more general application than the well known flexible metallic tube that may be connected to the delivery pipe on the machine and bent to deliver lubricant to the tools and work in exactly the desired position and direction. Tubes of this kind are made in different standard lengths so that they may be coupled onto the machines, and they make a very convenient method for applying lubricant to drills, lathe tools, etc., where the fluid is not required to be distributed over a wide area; such tubes also may be used to advantage for connecting the machine supply pipe with different forms of nozzles, examples of this kind being shown at *B* and *C*, Fig 22.

At *X* is shown a method of lubricating twist drills used for drilling thin metal plates *b* on a drill press not provided with means for circulating the lubricant. When this job was first turned over to the machine operator he was instructed to lubricate the drill from time to time with oil from a squirt can, but this method proved slow and tedious, and the operator devised the substitute shown in this illustration. It will be seen to consist of a shallow pan *c* filled with oil and a support *d* over this pan which holds work *b* ready for drilling. Support *d* has a hole drilled in it, and after passing through the work the tip of the drill dips into the oil before its travel is stopped. In this way the drill is provided with a supply of lubricant each time it completes cutting one hole and none of the operator's time is taken up in applying oil with a brush or squirt can.

Methods of Delivering Coolants to Grinding Wheels

Various forms of nozzles and distributors are used for delivering coolants to grinding wheels and work that is being ground. A number of devices for this purpose are illustrated in Fig. 24. At *A* is shown one of the simplest methods of delivering coolant to a grinding wheel; it will be seen that this consists of a pipe *a* arranged to throw the fluid tangentially against the wheel at the point where it is in contact with the work. A shut-off cock *b* provides for stopping the flow of coolant when so desired. This device is used on the

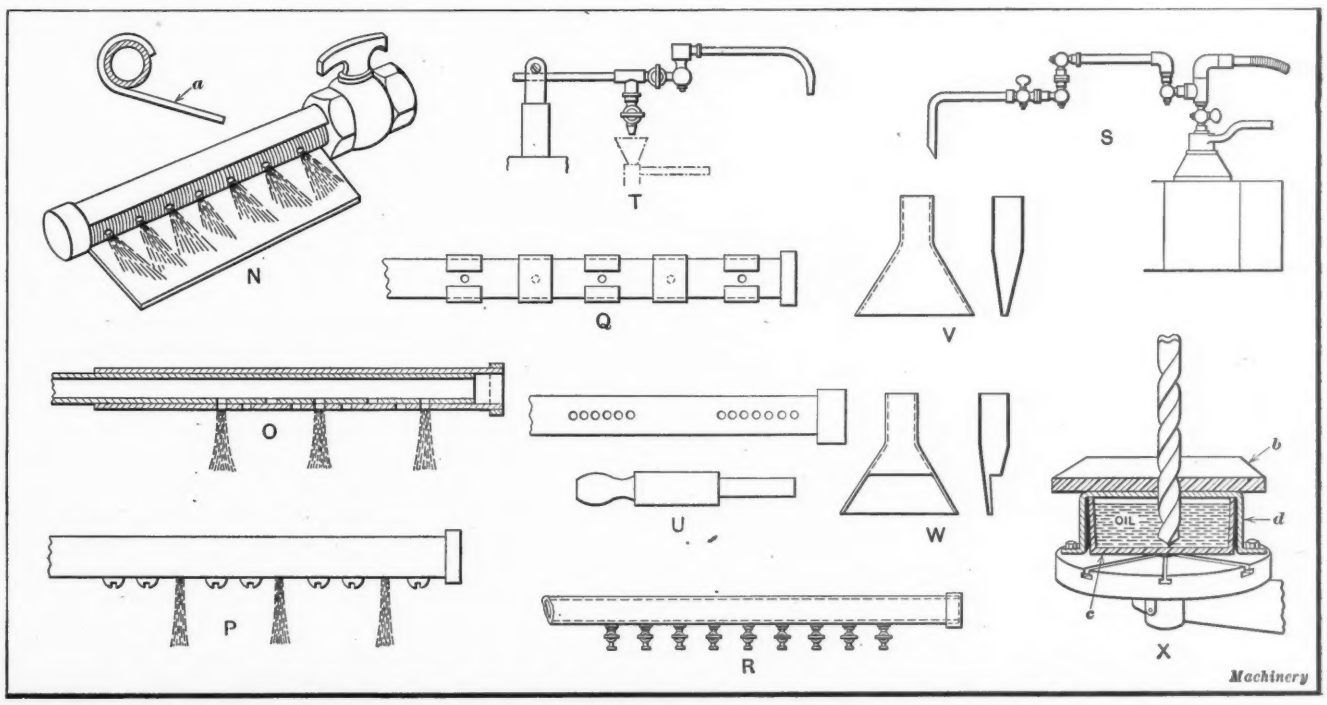


Fig. 23. Other Examples of Designs for Lubricant Pipe Nozzles and Delivery Tubes

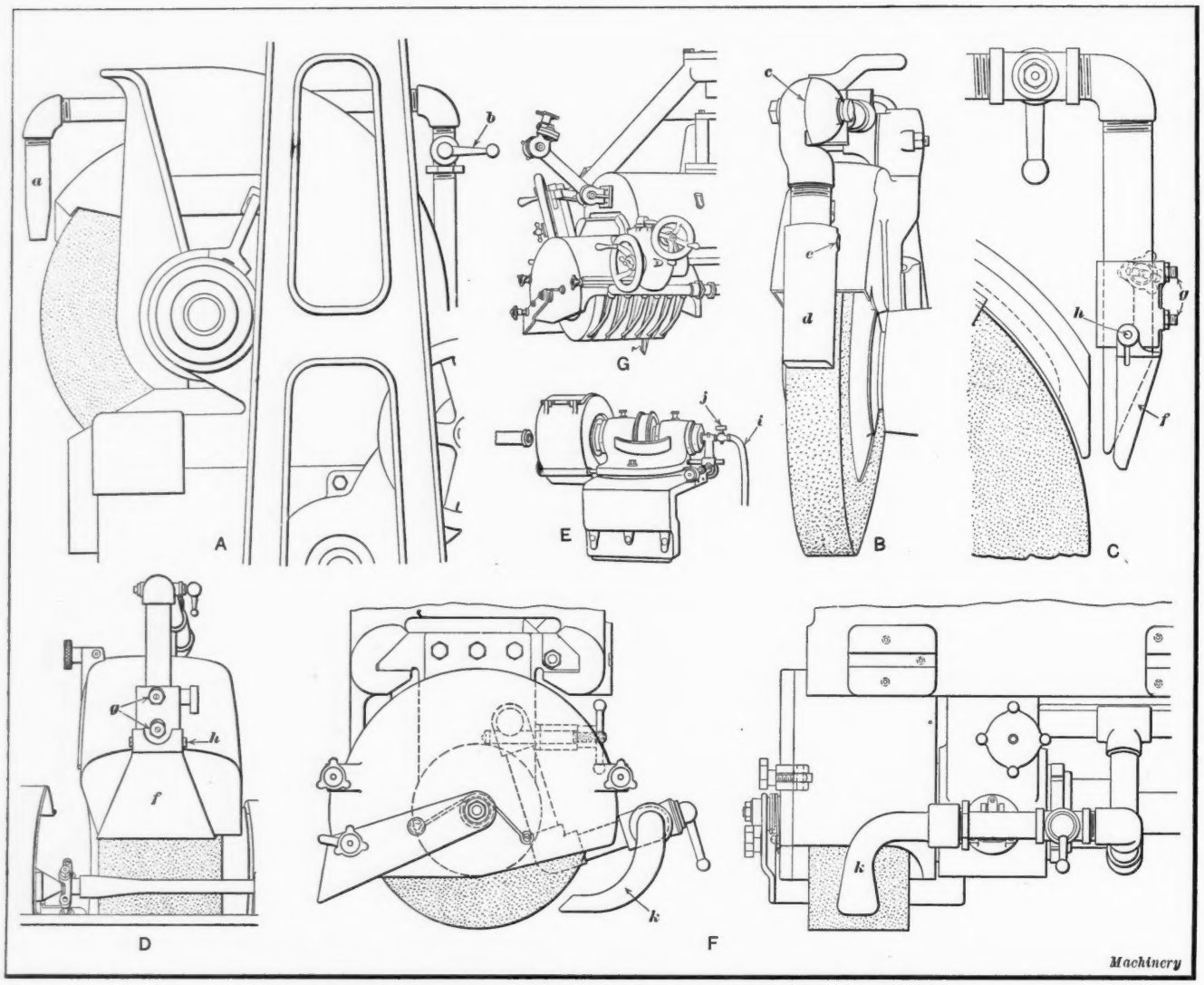


Fig. 24. Miscellaneous Examples of Distributors for delivering Coolants to Grinding Wheels

car wheel grinder made by the Norton Grinding Co. of Worcester, Mass., and is applicable for other classes of cylindrical grinding. In this case no attempt has been made to provide fine adjustment of the way in which the fluid strikes the wheel, and for machines working on those classes of grinding where such adjustment is necessary special devices must be provided. At *B* is shown a supply pipe and distributor used on cylindrical grinding machines built by the Landis Tool Co. of Waynesboro, Pa. Here it will be seen that the pipe is jointed at *c* so that the angle and position at which the fluid strikes the wheel may be adjusted. At the end of the pipe there is a distributor *d*, the position of which may be regulated vertically on the pipe by loosening screw *e*. At *C* and *D* are shown two forms of distributors used on Norton grinding machines; these are provided with means of adjusting the stream of fluid which strikes the wheel, and the design is the same in both cases except that a broad distributor is used at *D* to provide for spreading the fluid over a wide-faced grinding wheel. Distributor *f* may be adjusted vertically on the pipe by loosening screws *g*, and the distributor swings about a pivot *h* that enables it to be set at any desired angle. It will be evident that in the case of the nozzles shown at *B*, *C* and *D* a shut-off cock is provided to enable the flow to be stopped when so desired. Adjustment of distributor *f* governs the supply of water, the force with which it strikes the wheel and work, and the form that it takes after leaving the spout. The distributor is locked in place by the knob at the right-hand side.

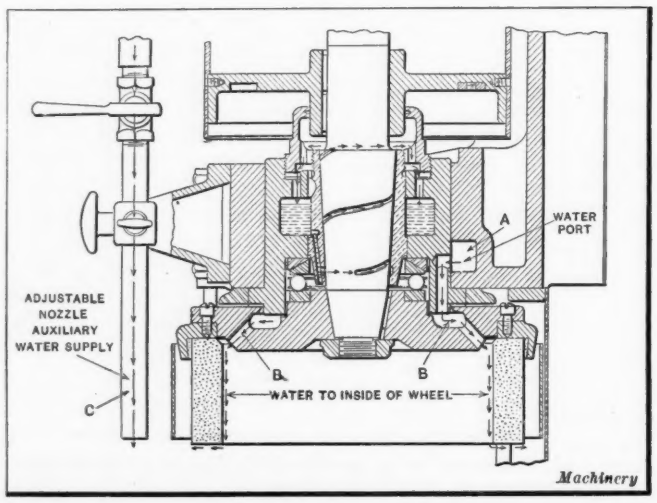


Fig. 25. Means provided for delivering Coolant to Surface Grinder made by Blanchard Machine Co.

For internal grinding it is the practice to deliver coolant to wheel and work through the hollow work-spindle, and at *E* are shown the means provided for this purpose on the internal grinding machines built by the Heald Machine Co. of Worcester, Mass. Coolant is carried to the hollow work-spindle through pipe *i*, and a cock *j* enables water to be turned on or off as required. On internal grinding, particularly on small work, it is highly important to provide for delivering the required volume of coolant at low pressure, because if the fluid were delivered under any appreciable pressure, it would be thrown out from the work with considerable violence. In grinding gasoline engine cylinders and similar work, the cooling action is provided in a different way; instead of delivering coolant direct to the wheel, water is circulated through the water jacket of the cylinder casting, which keeps the temperature of the work low enough so that it will not be burned. At *F* is shown the method by which coolant is delivered to Norton surface grinders. Here it will be seen that a pipe *k* delivers

the fluid to the wheel, and the position of this pipe may be readily adjusted to regulate the angle at which the fluid is delivered. A special application of such delivery pipes for use on a surface grinder where there are six wheels is shown at *G*. Here it will be seen that there are six nozzles leading from one manifold to provide for supplying each grinding wheel with the required volume of coolant.

On Blanchard surface grinders the work is carried on a rotating table which runs in the opposite direction to the cup-wheel, and in this case the method of delivering coolant to the wheel and work is provided in the design of the machine, as shown in Fig. 25. From the pump a 1-inch pipe runs to the wheel head, where it connects with a cored passage *A*, from which water passes down into the annular recess *B* in the faceplate and thence outward and downward inside the grinding wheel. The water in passing through the inclined holes in the faceplate is whirled at the full speed of the wheel, and issues from under the cutting face with considerable force, so that it thoroughly cleans the wheel face in addition to affording the required cooling action. An auxiliary adjustable pipe *C* is provided to deliver a heavy stream of water directly over the work table. Both inside and outside pipes have independent valves. A generous supply of fluid is particularly desirable in grinding dies and other hardened work where overheating would be very detrimental.

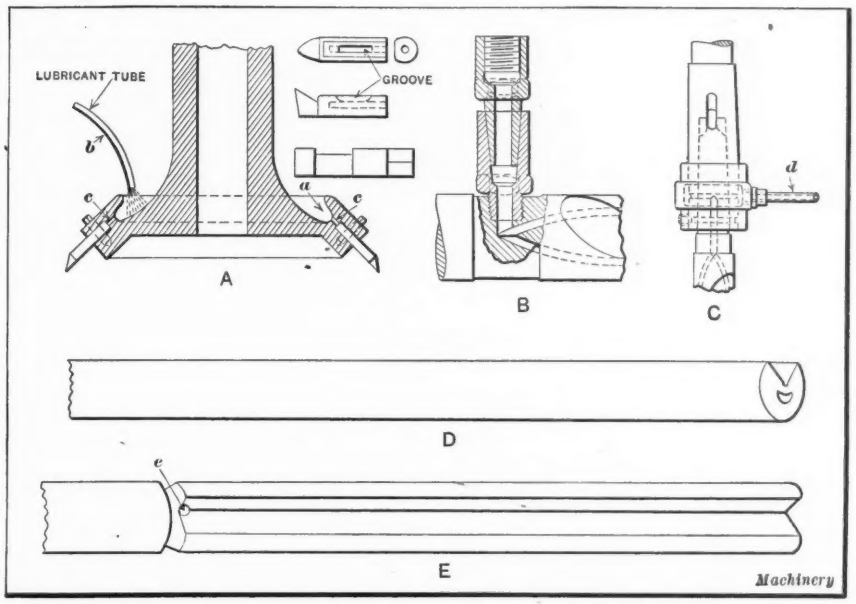


Fig. 26. Methods of delivering Lubricant to Oil-tube Tools—Drill and Reamer for Deep Holes

Designing Tools to Provide for Lubrication

In designing cutting tools it is sometimes possible to make provision for the delivery of lubricant which will be the means of producing more satisfactory results than would otherwise be the case. An example of this kind is shown at *A*, Fig. 26, which consists of an inserted-tooth milling cutter used on a vertical milling machine. It will be seen that a groove *a* is provided around the head of this cutter into which lubricant is delivered by pipe *b*. From this groove holes *c* connect with each of the inserted-tooth cutters, and these, in turn, have a hole drilled at the upper end and a groove cut in the side to allow lubricant to reach the point of the tool. In this way the fluid goes right to the cutting point, where it is most necessary.

At *B* and *C* are shown two typical methods of making connection with oil-tube drills and similar tools. At *B* the tool remains stationary and the work revolves, so that it is possible to deliver oil through a tube threaded into the side of the drill. At *C* the drill revolves while the work remains stationary, and in this case a collar which is a sliding fit on the drill makes connection with the oil-tubes in the drill, oil being delivered through small pipe *d* to an annular space in the collar. For deep-hole drilling and similar work the action of the oil in washing chips out of the hole is very important, and in order to be effective the oil should be delivered at high pressure. An extreme case in deep-hole drilling is seen in drilling rifle barrels, this work being done by a tool of the form shown at *D*. It is of the oil-tube type, the drill point being made of steel and brazed to the end of a steel tube. This tube is rolled in such a way that a groove is formed down one side; oil is delivered through the center of the tube and through oil-tubes in the drill point, and returns by way of the outside groove through which the chips are washed out. As the oil is delivered at a pressure of about 800 pounds per square inch, care must be taken to prevent it from splashing, and for this purpose a guard is furnished which surrounds the end of the work to catch the oil and chips and divert them into the pan of the machine, a guard for this purpose being shown at *C*, Fig. 20. A deep-hole reamer of the oil-tube type is shown at *E*, Fig. 26, oil for lubricating the tool and washing away chips being delivered through hole *e*.

Machine Design as Applied to Tool Lubrication

The forms of distributing tubes and nozzles shown in Figs. 22 and 23 may be connected to the delivery pipe on practically any form of machine, and do not involve alteration of the original design in any way. But there are many cases where it is necessary to work out the design of machine members in order to provide for delivering lubricant to cutting tools, and typical examples of this kind are shown in Fig. 27. A simple form of lubricating device for use in connection with oil-tube tools is shown at *A*. It consists of a flexible tube *a* attached to the oil pipe *b* leading from the pump. The flexible tube is attached to the back end of tailstock spindle *c* and the oil flows through the hollow tailstock spindle to the tool. This device is used on automatic screw machines built by the Cleveland Automatic Machine Co., Cleveland, Ohio. This firm also uses an automatic shut-off device shown at *B*, which consists of an oil cock *d* having a special four-pointed star on its stem, which is turned to shut off or open the oil cock by adjustable pins *e* mounted on cam drum *f*. This is an extra attachment

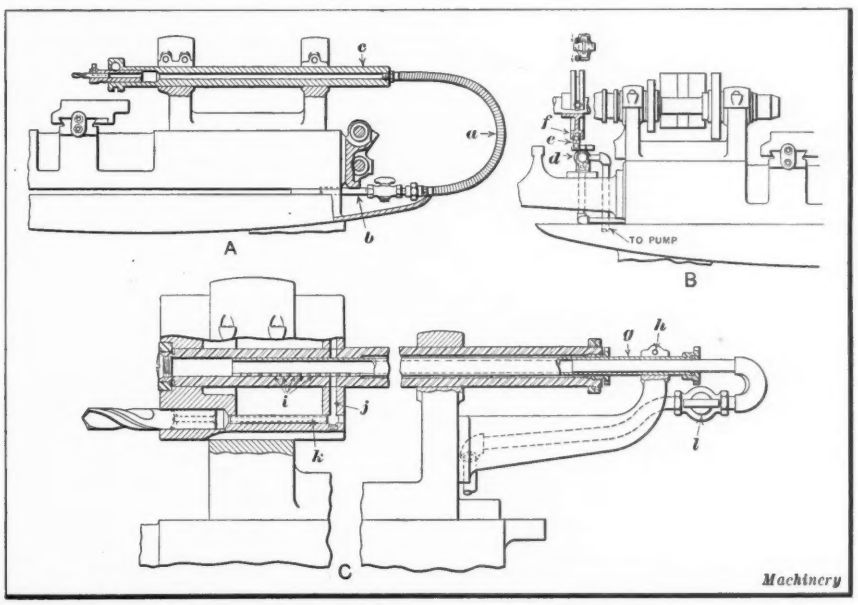


Fig. 27. Examples from Practice of Cleveland Automatic Machine Co. in delivering Lubricant to Oil-tube Tools

which is supplied with the oil feed when required, but the device shown at *A* meets all requirements in most cases, allowing the oil to feed through the cutting tool continuously.

At *C* is shown a lubricating device, which is also used on machines made by the Cleveland Automatic Machine Co., that provides for delivering oil to each turret hole, so that oil-tube drills, reamers, boring tools, counterbores, etc., may be placed in any or all turret holes as required. The valve mechanism which controls the flow of oil to different turret holes permits its flow only to the tool which is actually cutting, and automatically shuts off the oil from all the other holes. Starting and stopping the flow of oil is accomplished by forward and backward movement of the turret shaft. Oil-tube *g*, which extends inside the turret shaft, comprises the valve that controls the flow of oil, this tube being adjustable longitudinally and clamped in any position by screw *h* in the oil-feed bracket. At the forward end of tube *g* there is a series of holes *i* arranged in a single row at the lower part of the tube and extending over a length equal to the turret stroke. Oil-tube *g* is held stationary at all times, and when the turret shaft moves forward and backward on its regular stroke, hole *j* in the turret passes over this series of holes in the tube, allowing oil to flow through hole *j* and tube *k* to the turret hole and thence through oil-tubes in the tool. Oil is only delivered to the lowest turret hole, which is in line with the spindle of the machine; all other holes in the turret are shut off. The position in which oil-tube *g* is clamped determines when the flow of oil will commence; in other words, it is possible to have the flow of oil through the tool for the full length or any part of the stroke, the idea being that if the work is short, the oil will not start to flow until the tool has reached the work; it is for this reason that adjustment of oil-tube *g* is provided. The supply of oil may be shut off by closing valve *l* if so desired, this valve being placed in the main delivery pipe leading from the pump.

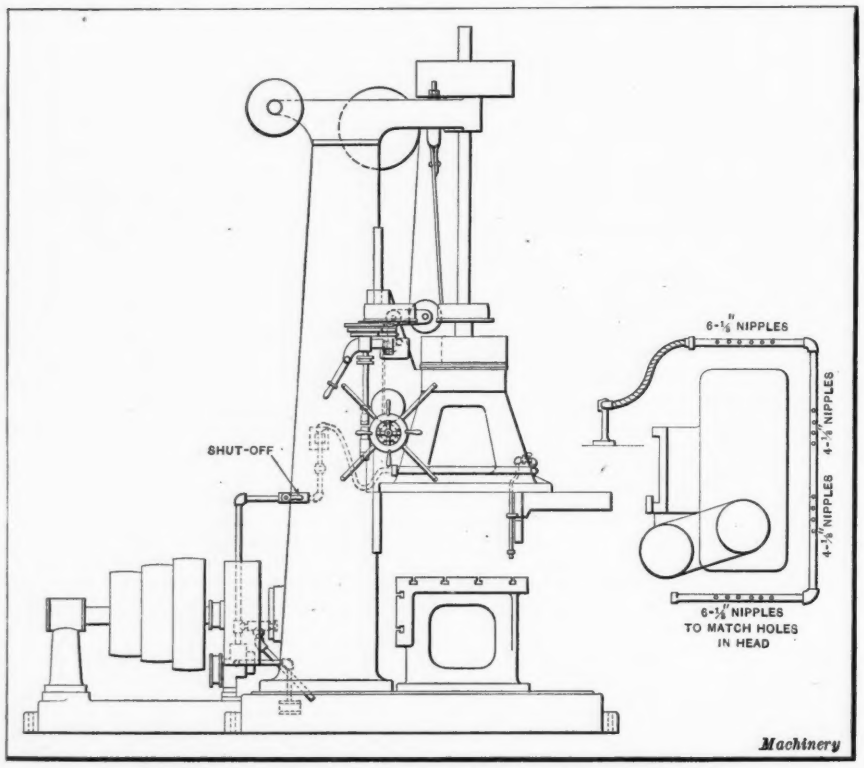


Fig. 28. Lubricating System on Baush Multiple-spindle Drilling Machine

Too much emphasis cannot be laid upon the desirability of having machine tool builders provide all the equipment necessary for delivering cutting compound to the tools on the machines which they manufacture. We frequently see machines of otherwise excellent design which the user has rigged up with most obvious makeshifts for the delivery of lubricant to the tools; but even under the most favorable conditions it cannot be expected that men in the user's factory, who are specialists in the production end of a business, can design devices for tool lubrication that will be as efficient or look as well as those worked out by designers in the machine tool builder's factory. It has been stated that practice in the lubrication of cutting tools is often far below the standard of manufacturing efficiency in other branches of the productive system in many factories, and the same condition is true of machine design, as the development of means for tool lubrication on many machines is far below the average of excellence attained in other branches of design.

The sort of devices with which machine tools should be equipped are illustrated in Figs. 28 and 29. The first of these shows a multiple-spindle drilling machine made by the Baush Machine Tool Co., Springfield, Mass. It will be seen that there is a flexible tube connecting the head to the piping system to provide for movement of this head. A distributing pipe runs around the lower end of the head with an individual tube

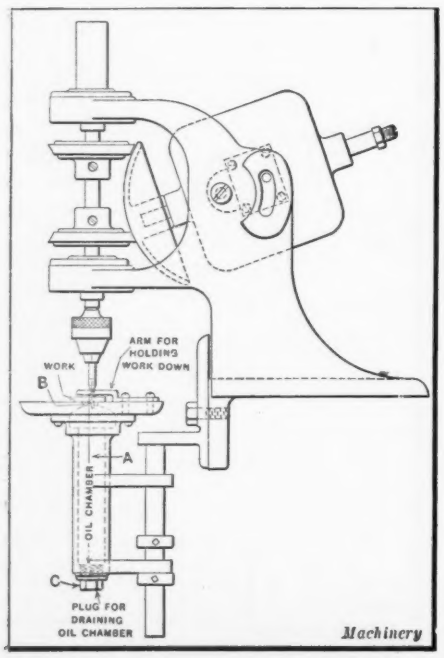


Fig. 29. Provision made for Tool Lubrication on Anderson Variable-speed Tapping Machine

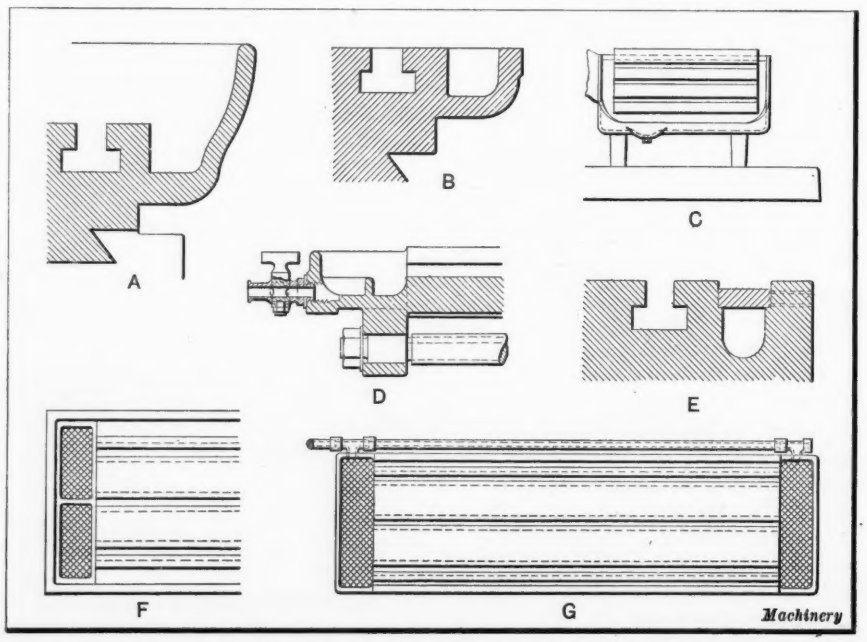


Fig. 30. Miscellaneous Examples of Table Trough Design, showing Means of separating Chips from Fluid

connected to each spindle; and each tube has its individual shut-off, so that lubricant is not delivered to those spindles which are not in use. Also there is a shut-off in the main supply pipe for shutting off the entire flow of lubricant, and a relief valve provides for maintaining the desired pressure at which lubricant is delivered to the drills.

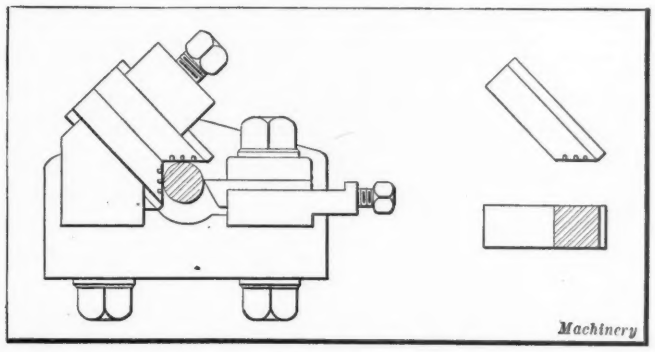


Fig. 31. Practice of grooving Jaws on Back-rests to facilitate Lubrication

Fig. 29 shows a device for lubricating small taps, used on a variable-speed tapping machine that has just been placed on the market by the Anderson Die Machine Co. of Bridgeport, Conn. It will be noticed that the vertical stem that supports the work table is made hollow to provide an oil chamber *A*. In this table there is a small hole *B* through which the tap passes, and the level of oil in chamber *A* is kept up to the top surface of the table. Each time the tap passes through the work it dips into the oil, thus washing off chips and providing the tap with a fresh supply of lubricant for the next cut. The chips drop to the bottom of the oil reservoir, and in addition to preventing damage of the thread while the tap is being backed out, tend to keep the level of oil in the reservoir high enough so that the tap will always dip into it. When the reservoir becomes filled with chips, threaded plug *C* is removed so that the reservoir can be washed out with kerosene ready to receive a fresh supply of oil.

Roller back-rests are superior to back-rests with adjustable jaws that do not rotate, provided the oil or cutting compound is of such a character that it will not gum the rollers and prevent them from moving freely. When stationary back-rests are used it is good practice to have the jaws grooved as illustrated in Fig. 31 to carry oil around the stock, so that friction will be eliminated and the jaws will not mar the finish produced by the tools. Users of cutting oil should not conclude that satisfactory results obtained from stationary back-rests that have not been grooved are due to a superior quality of oil or cutting compound, for as a matter of fact this is likely to be an indication of tendency of oil to gum, and the use of such oil should always be avoided.

Methods of Collecting Oil or Cutting Compound

In the discussion of methods of delivering lubricant to the tools and work, it was mentioned that one of the simplest means was to provide a drip can from which a small stream of oil or cutting compound is delivered to the tool. Similarly, the simplest means of collecting the fluid for subsequent use is to have a can suspended under the machine, into which the lubricant drains after running over the tools and work. This method is commonly used in connection with the drip can, and when the receiver becomes full its contents are poured back into the drip can from which lubricant is delivered to the tool. This system is inadequate when the supply of lubricant required is so great that it becomes necessary to empty the can at frequent intervals.

Necessity for tool lubrication is now generally recognized, and

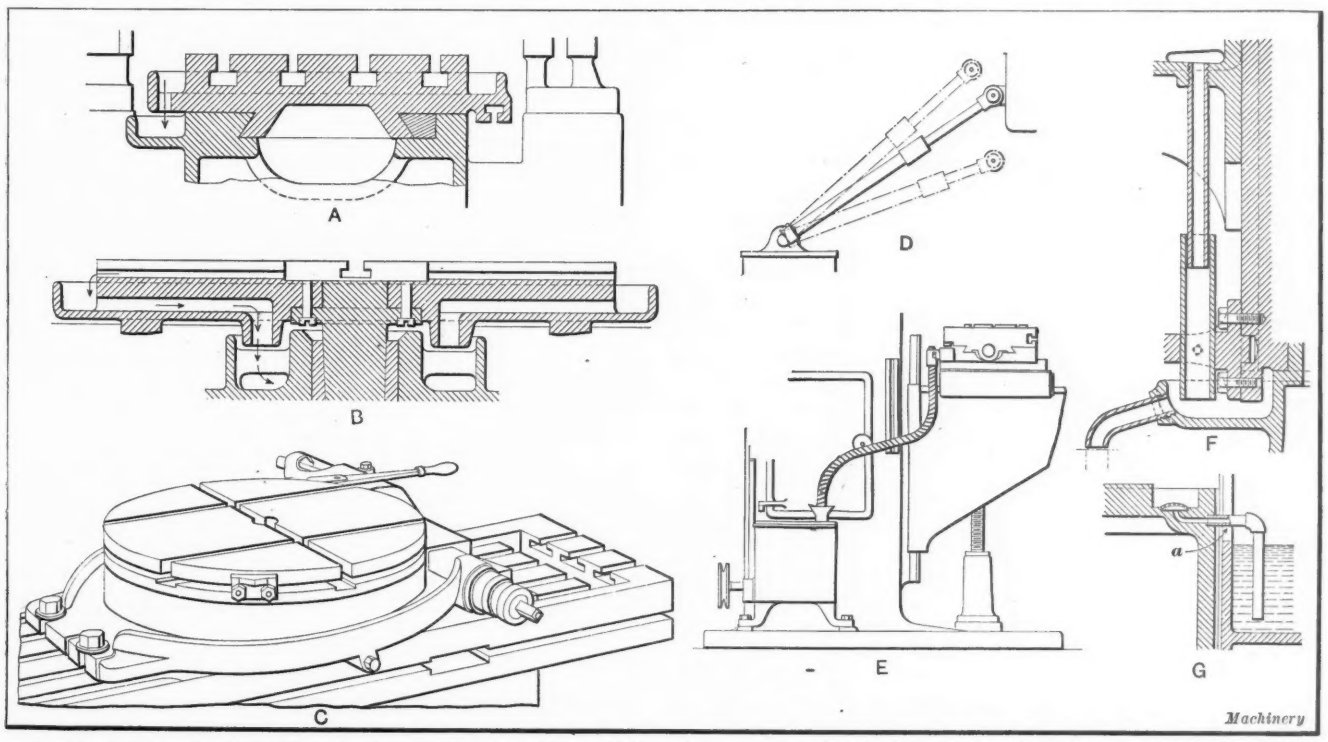


Fig. 32. Methods of making Connection between Trough on Moving Table and Reservoir in Machine from which Lubricant is pumped back to Work

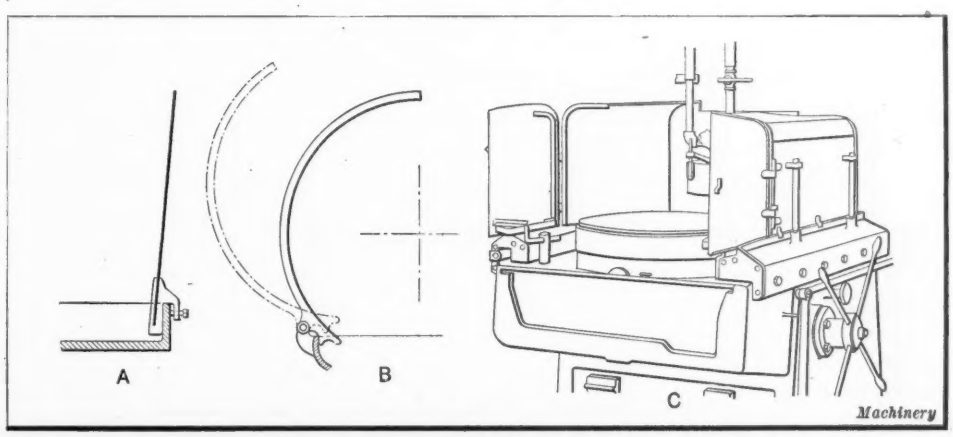


Fig. 33. Examples of Splash Guard Design; at C is shown Guard which affords Absolute Protection

provision is made on most machine tools for collecting the lubricant and pumping it back to the tools. The usual method of collecting fluid is to have the familiar oil trough surrounding the work table, and Fig. 30 shows different examples of this kind. At *A* the rim surrounding the oil trough extends up above the table level, which is a desirable feature where the work or fixtures do not project beyond the table. At *B* the same design is shown except that the rim surrounding the trough is made flush with the table surface to allow overhang of the work and tools. A similar construction is shown at *C*, which illustrates the oil trough surrounding a radial drilling machine table where there are both horizontal and vertical surfaces on which to clamp the work. It is important to prevent chips finding their way into the oil reservoir from which the pump draws its supply, and a simple method of accomplishing this is shown at *D*, where it will be seen that there is a small weir surrounding the outlet. The same purpose is served by the cover plate shown at *E*, which extends over the oil trough; and at *F* a screen is provided at the end of the trough from which oil is drawn off to be returned to the reservoir. A slight modification of the oil trough system is shown at *G*, in which it will be seen that a large reservoir is provided at each end of the table, connected by small oil troughs and also by a pipe through which the oil is drawn off to be returned to the reservoir.

There are numerous methods of making connection between the oil trough in the table and the reservoir from which oil is pumped back to the work. At *A* and *B* in Fig. 32 are shown two simple methods of collection for use on reciprocating and rotating tables, respectively. Here it will be seen that drain channels on the moving tables are arranged in such a way that they are always located over fixed channels from which connection is made with the reservoir. At *C* is shown the method of draining lubricant from a rotary milling machine table. When the range of movement is too great to make it possible to apply the principles of design shown at *A* and *B* or when trouble may be experienced from splashing of the oil or cutting compound, some other form of construction must be applied. In many cases use may be made of telescopic tubes which provide for table movement in both a horizontal and vertical direction, an example of this kind being shown at *D*. In similar cases a flexible tube may be used, as illustrated at *E*, provided the length or position is not such as to inconvenience the machine operator. When it is merely necessary to take care of vertical movement, as in the case of tables on drilling machines, etc., the oil trough surrounding the table may be conveniently drained by a telescopic tube as shown at *F*, or by a tube which slides in a vertical slot *a* as illustrated at *G*.

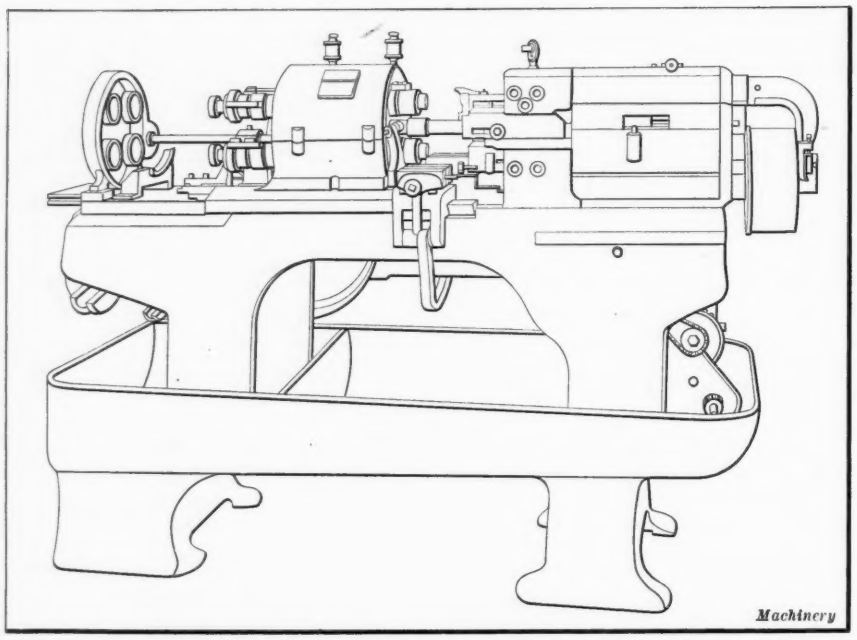


Fig. 34. "Radical" Automatic built by Fitchburg Automatic Machine Works—Chip Pan is of Ample Size to prevent Oil from dripping onto Floor

When trouble is experienced from the throwing of oil or cutting compound from high-speed machinery, splash guards must be provided, common examples of this kind being seen on most grinding machines. Fig. 33 shows three typical examples of splash guard design. At *A* the flat guard is secured by a clip which enables the guard to be removed for inspection or adjustment of the machine. At *B* a curved guard is shown which is hinged, and it is common practice to have two such guards located at each side on grinding machines, automatic screw machines, etc., so that the moving part is completely enclosed, making it impossible for oil to be thrown onto the floor or to soil the operator's clothing. The type of guard shown at *C* is used on grinding machines built by the Blanchard Machine Co., Cambridge, Mass. As the table moves out to remove finished work and reload the chuck, the doors open automatically and they close in the same way when the table moves back under the wheel. This excellent design makes it impossible for spray to be thrown from the wheel and does not delay the operator.

Arrangement of Oil and Chip Pans

To facilitate catching oil and cutting compound used on machine tools, it is now common practice to provide machine tools with pans which are familiar to all those who are employed in or have occasion to visit machine shops. It will not be out of place, however, to refer briefly to this feature of machine tool design. Many machine tool builders make a practice of constructing all machines with oil pans in order to standardize their designs, and a pump and oil circulating system can then be provided on those machines intended for work on which lubricant is used. In all cases the pans should be of sufficient size to make it impossible for oil and chips to fall on the floor. Many machinery builders do not pay attention to this point, with the result that their customers are forced to add unsightly extensions to oil pans on their machines. Buyers of machine tools should insist upon having oil pans extended well out from the machine, as shown on the machine illustrated in Fig. 34.

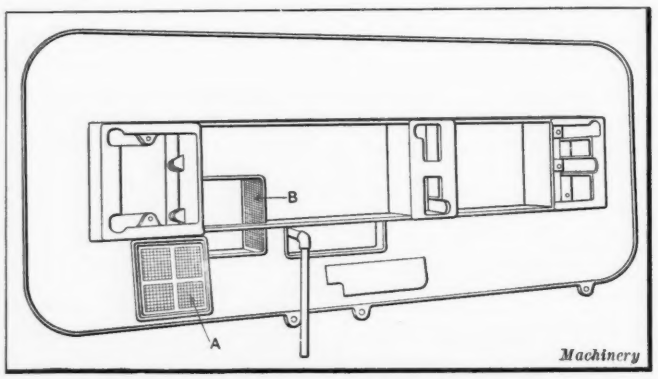


Fig. 35. Oil Pan used on Automatic Screw Machines built by Cleveland Automatic Machine Co., showing Efficient Strainers to insure Complete Removal of Chips

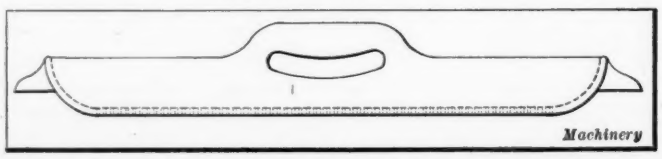


Fig. 36. Perforated Tray for Use inside Oil Pan to facilitate Removal of Chips

In designing oil and chip pans careful attention should be paid to the provision of means for removing all chips and grit from the oil before it is pumped back to the work. This is important for two reasons: first, chips and grit in the oil tend to damage both the lubricant pump and bearings of machine tools to which the lubricant is delivered; second, dirty oil is less efficient as a lubricant and

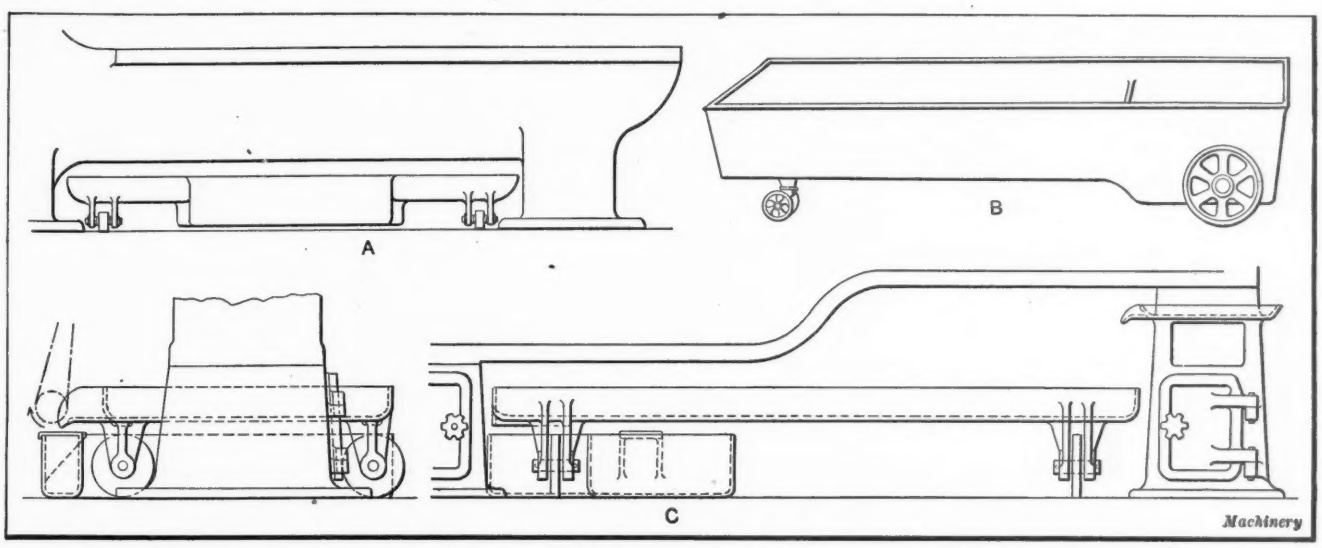


Fig. 37. Portable Oil Pans which can be used to Advantage under Automatic Screw Machines, etc., making Removal of Chips an Easy Matter

coolant. Buyers would do well to insist upon having suitable provision for cleaning the oil for subsequent use. Fig. 35 shows a good example of oil and chip pan design used on automatic screw machines made by the Cleveland Automatic Machine Co., Cleveland, Ohio. The strainer *A* is perforated with large holes, allowing lubricant to pass through freely. The screen *B* has small perforations through which the lubricant passes more slowly, thus allowing foreign matter to settle to the bottom. The pump suction pipe shown dipping into the well is fitted with another fine strainer. The consequence is that the oil passes through three strainers before reaching the pump and work, which means that it is pretty sure to be free from chips.

In showing examples of different manufacturers' practice in designing various machines, it is not the intention to imply that the examples shown are the best; but they have been selected at random to indicate the features of design that should receive careful attention in dealing with the problem of tool lubrication. In some cases straining of chips from oil or cutting compound is accomplished by placing a separate strainer in the chip pan or above the reservoir inside the machine. Such strainers should be furnished with handles, as in the case of the one illustrated in Fig. 36, so that they may be easily lifted out. The limitation of this practice is that unless particular care is taken a lot of lubricant is likely to drip onto the floor while dumping the contents of the strainer into a truck, thus tending to create an unsanitary and unsafe condition in the factory.

An alternative system is to use portable oil pans as shown in Fig. 37, which can be run into place under a machine and removed at will. Such pans are used in factories where certain classes of work call for the use of oil or cutting compounds, while other classes of work can be machined dry. In addition, many manufacturers prefer the use of portable pans on automatic screw machines and other tools that produce a large quantity of chips, as the use of such pans facilitates the removal of chips. Automatic screw machines built by the New Britain Machine Co., New Britain, Conn., are furnished with portable pans of the type shown at *B*, which, it will be seen, is furnished with a strainer and sump into which oil drains ready for pumping back to the machine. In making rounds with an oil-tight truck, the man employed to remove chips from the machine swings the shallow end of the pan out from under the machine so that he can easily shovel the chips into the truck. The pan is then pushed back and the whole operation takes but a few minutes.

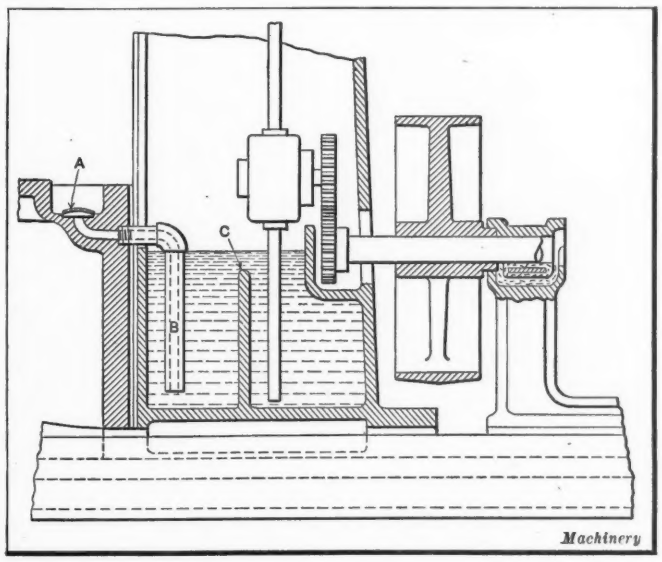


Fig. 38. Partial Sectional View of Frame of Drilling Machine built by Sibley Machine Tool Co., showing Arrangement of Lubricant Reservoir

Provision of Pump Reservoirs in Machines

The design of reservoirs in which oil or cutting compound is collected to be pumped back to the work is governed by the class of machine and kind of work to be done. In nearly all cases, strainers or other means provided in oil and chip pans for the removal of chips and coarse dirt from the fluid allow some finely divided material to pass, and provision should be made in the reservoir for the removal of as much of this suspended matter as possible. Common practice is to divide the reservoir into separate compartments by means of baffle plates over which the fluid must flow; and the first compartment into which the fluid comes from the chip pan should be of sufficient size to allow time for suspended matter to settle to the bottom before the fluid reaches the section of the reservoir in which the pump suction pipe is located. In cases where considerable heat is developed by the machining operation, which must be absorbed by the cutting compound, this large reservoir serves another purpose in that it exposes a considerable surface of the fluid and facilitates radiation of heat. In developing oil mixtures and cutting compounds a great deal of thought has been paid to the development of fluids which radiate heat readily. With properly designed reservoirs and fluids of this kind, tests conducted by suspending an accurate thermometer in the reservoir show that the temperature of the fluid does not rise appreciably during an entire working day.

With the evolution of machine design it became evident that in most cases the best location for the oil reservoir is inside the hollow frame casting on milling machines, drill presses, lathes and other machine tools, because this constitutes a space in which lubricant can be stored, and the position is such that the reservoir does not take up space that is not actually required for the machine. Fig. 38 illustrates a sectional view of a drilling machine column with a reservoir provided in this way; and Fig. 39 shows a similar sectional view of

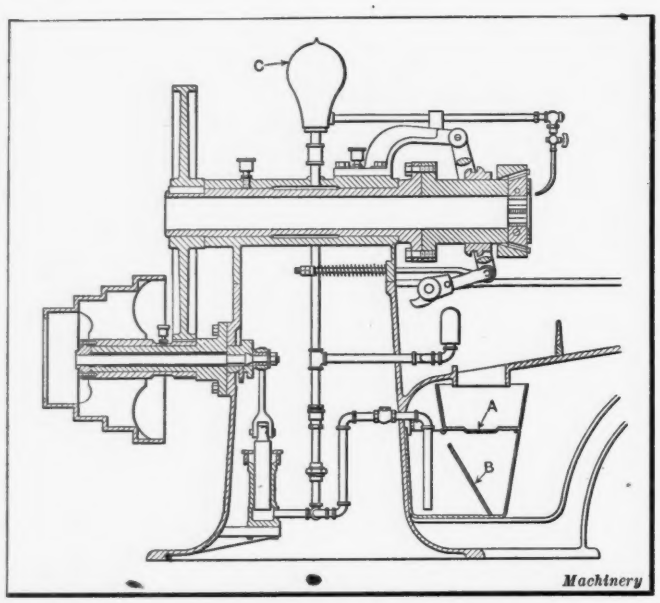


Fig. 39. Sectional View of Bolt Threader built by National Machinery Co., showing Means of distributing and purifying Cutting Compound

a bolt threading machine. In all cases of this kind it is of the utmost importance to provide for the removal of chips, dirt and other foreign matter from the fluid before it reaches the suction chamber from which the pump delivers it back to the tools and work. In the drilling machine column, Fig. 38, the lubricant collected in the trough surrounding the table runs through strainer *A* into drain pipe *B*, which extends down close to the bottom of the reservoir. Any fine material which gets through the strainer settles by gravity while the fluid runs over baffle plate *C* into the suction chamber. It will be noticed that the pump used in this case is direct-connected by gearing from the main driving pulley shaft.

In the bolt threader shown in Fig. 39, the lubricant runs back into the reservoir, which is furnished with a strainer *A*; in this case the strainer is made separate from the reservoir so that it may be lifted out for removing the chips. The pump suction connects with the lower section in this reservoir, and it will be noticed that an inclined plate *B* is located in such a way that any fine chips which pass through the strainer will settle at the right-hand side of this plate, while the pump suction located to the left is thus assured of obtaining a supply of clean lubricant. The pump, which is of the plunger type, is direct-connected to the driving shaft, and in order to equalize pressure as far as possible an air bell *C* is provided, which cushions variations that would otherwise exist.

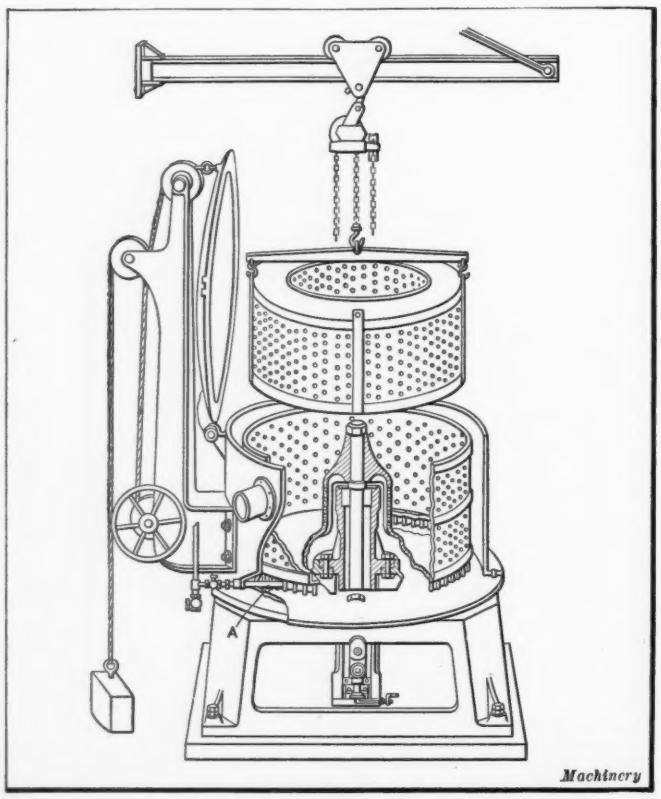


Fig. 40. Turbine-driven Centrifugal Chip Separator built by Oil & Waste Saving Machine Co.

Removal of Oil from Chips with Centrifugal Separators

There are many factories in which the management is prone to think that advantage is taken of every method of improving efficiency and reducing manufacturing costs, but in which chips are sent to the foundry that have a lot of oil sticking to them. This is apparent when the chips have been standing at the scrap pile for a sufficient length of time to allow a considerable amount of oil to drain off; and sometimes the oil becomes rancid, in which case its presence is made evident by the disagreeable odor. In most plants operating automatic screw machines or other tools which produce many chips, centrifugal separators are employed to remove oil before the chips are sent to the foundry to be melted. In the

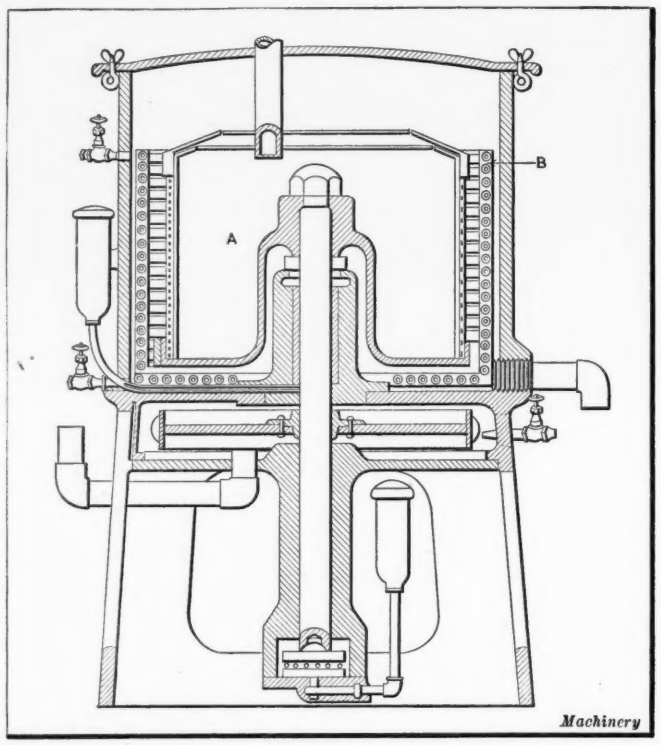


Fig. 41. Oil & Waste Saving Machine Co.'s Turbine-driven Centrifugal Filter and Drier for purifying Oil recovered from Chip Separator

operation of these separators there is another chance for the wasting of lubricant. If the chips are conveyed from the machines to the separator in a leaky wheel-barrow, there is every opportunity for part of the oil adhering to them to drain out onto the floor and be wasted. If workmen could be led to regard each gallon of oil as the equivalent of from twenty-five cents to one dollar, according to the class of oil and market conditions at the time of its purchase, it is certain that all conscientious men would be more careful in handling this material. Oil-tight trucks are available for carrying chips, and investment in one or more trucks of this kind is strongly recommended, both as regards oil economy and the maintenance of sanitary conditions in the shop.

The character of the chips will govern to some extent the efficiency of the separators for removing oil from them. The easiest chips to handle are those which are long and curly, so that the oil is not too closely confined in the mass of chips; conversely, it is most difficult to make a complete extraction of oil from fine chips, and saw swarf is about the most difficult material to handle. The consensus of opinion among manufacturers seems to be that the most complete extraction of oil is obtained with the smaller sizes of centrifugal separators, and probably this is due to the fact that there is not such a large mass of chips in the separator at any one time. On the other hand, the cost of handling chips and oil is greater in

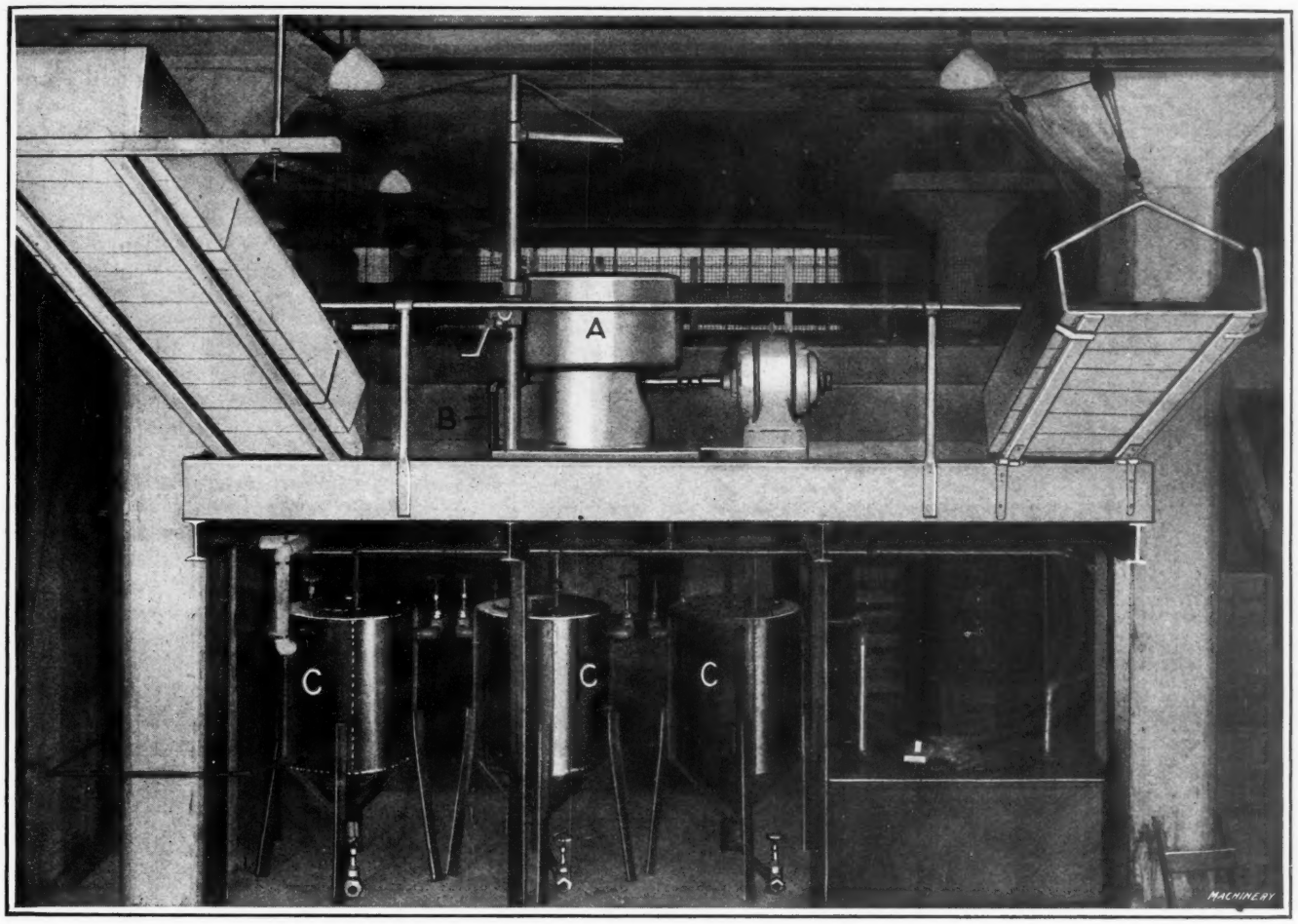


Fig. 42. Good Arrangement of Centrifugal Separator and Filters

the case of small separators, which must be stopped at frequent intervals to recharge. With kerosene, experiments have shown that 140 pounds of chips are capable of holding one gallon of oil, and for lubricants of higher viscosity the amount of oil held by the chips would be greater. For instance, thirty pounds of chips will hold about a gallon of mineral lard oil. This is sufficient to emphasize the importance of installing centrifugal separators to remove the oil, and in order to obtain a satisfactory degree of efficiency tests should be made at regular intervals to determine the time chips should be left in the separator and the speed to prevent unnecessary loss of oil.

Where a lot of chips are handled it is good practice to pile them on a grid so that the oil may drain through and be collected, thus reducing the time required for centrifugalizing. In some plants conveyors may be used to advantage for carrying chips to the department where oil is recovered. Settling tanks may be employed in making a preliminary purification of oil before it is filtered, and the centrifugal separator department should be conveniently located for sending chips back to the foundry.

Fig. 40 shows a centrifugal chip separator built by the Oil & Waste Saving Machine Co., Philadelphia, Pa., that is driven by a direct-connected steam turbine. The chips are contained in a rotating basket and the high speed of rotation results in removing the oil by centrifugal force. It will be seen that a special hoist raises the chip basket, making it easy to remove the dry chips and substitute a fresh charge. The nozzle through which steam is delivered to the turbine is shown at *A*, and after passing the turbine wheel the steam heats the chips, thus making the oil more fluid and facilitating the action of centrifugal force; it is also claimed that this raising of temperature serves to sterilize the oil. A minimum efficiency of 98 per cent is claimed for the turbine-driven separators. These chip separators are made in two sizes, with baskets which have capacities for holding 3½ and 8 cubic feet of chips, respectively. On the large machine the basket is 36 inches in diameter; the speed of rotation is 600 revolutions per minute; and the time required to remove the oil from a basketful of chips, including charging and removal, is ten minutes.

Condensed steam from the turbine forms an emulsion with the oil, and as this would have a detrimental effect on both tools and machines, it is desirable to remove it before the oil is used again. For this purpose the Oil & Waste Saving Machine Co. builds a centrifugal oil filter, shown in Fig. 41, which is also driven by a direct-connected turbine. Centrifugal force causes the oil to be driven through a series of filtering mediums composed of sawdust, cloth and paper, which line the chamber *A* in the machine, into which the oil is delivered continuously, thus removing all solid matter. The oil is sprayed upon steam-heated evaporating coils *B* which surround the filtering chamber, and in this way all water is removed and the oil is converted from an emulsion to a pure oil which is suitable for use under the most exacting requirements. This filter is made in two sizes, known as 15- and 20-inch sizes, respectively. In the 15-inch size the basket rotates at 1500 revolutions per minute. The cost of steam consumed per hour is two cents, based on coal at $4 a ton, and the filter has a capacity of purifying from twenty to thirty gallons of oil per hour. In the larger machine the filter runs at 1000 revolutions per minute; the cost of steam is three cents per hour, based on coal at $4 per ton, and the filter can purify from fifty to sixty gallons of oil per hour.

A good arrangement of centrifugal separator for the recovery of oil from chips is illustrated in Fig. 42. The scrap with oil sticking to it is thrown into the chute which will be seen at the left-hand side of the illustration, down which it descends to the separator platform, from which the chips are shoveled into the chip pan of the centrifugal separator *A* that is driven by an electric motor. The oil expelled from the chips by the separator flows down through pipe *B*, from which it is delivered to filters *C* which are steam-heated to increase the rate of filtering. After passing through these filters the clean oil is ready for use. The dry chips removed from centrifugal separator *A* are shoveled into the chute shown at the right-hand side of the illustration and dropped into a truck waiting to receive them. A run of from two to four minutes in the separator is usually sufficient to completely remove all oil from the chips.

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We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.

Douglas T. Hamilton, associate editor of MACHINERY for nearly seven years, has resigned to join the Fellows Gear Shaper Co., Springfield, Vt., as advertising manager. The increased value of MACHINERY'S reading pages during Mr. Hamilton's connection has been due, in no small measure, to his many practical articles on automatic screw machine practice, watch making, cartridge manufacture, motor car manufacturing practice, machine forging, grinding, electric welding, shrapnel and high-explosive shells, gages and other subjects. These thorough studies in manufacturing practice have set up a new standard in technical literature. Mr. Hamilton takes with him to his new work the cordial wishes of all his associates for his future success.

* * *

LUBRICATING AND COOLING CUTTING TOOLS

Important factors in the efficiency of metal cutting tools are the fluids used to lubricate and carry off the heat, and the means for applying them. It was known long ago that a burnished effect on wrought iron and steel could be obtained by dropping water on lathe tools when taking finishing cuts, but only within the past thirty odd years have some of the possibilities resulting from supplying a lubricant and coolant in quantity been recognized. During the past ten years "flood" lubrication to cool the tool and carry off the chips has received some of the attention that its importance demands.

The supplying of lubricant and coolant in large quantities to the cutting tools of machines requires considerable engineering ability, especially when a large department or plant has to be provided for. Hardly any two shops present the same problems; while in general it is conceded to be good practice to provide a common circulating system and reservoir from which the lubricant is forced through pipes to the machines and to which the used lubricant is returned for cleaning and purification, it is, nevertheless, sometimes preferable to provide an independent system for a machine or a group. Chip removal may be provided for in connection with portable chip and lubricant pans. Multi-story buildings present different conditions from those met with in single-story plants, and the fire hazard may be a serious matter which necessitates treatment of the problem in a way to minimize risk and reduce the insurance premiums.

The choice of a satisfactory cutting lubricant is not simple; it is generally conceded that there is no better commercial lubricant than pure lard oil, but the high cost of lard oil has made it imperative to use cheaper substitutes, of which there are a great number, differing in efficiency from very good to very poor. The chemistry of oils is complex and the physical characteristics of emulsions offer a field for investigation. Colloids may be discovered having the efficiency of deflocculated graphite but without its objectionable smut. In short, the need of low cost and effective cutting lubricants is likely to bring forth compounds much better than any now available.

The article on cutting lubricants and coolants in this number is the opening installment of the first adequate treatment of this important subject. It seems incredible that a subject so important to the metal-working industries has been so long neglected by engineers generally and that there should have been so little published data available. But it may be regarded as only one more of the factors in production efficiency that demands more attention of the factory engineer.

* * *

TREND OF MACHINE TOOL PRICES

The advances in selling prices which have been made by machinery builders during the past two years have led to considerable speculation concerning the trend of machine tool prices now that the demand for tools used in making munitions of war is less insistent. As this increase in price came at a time when practically all materials and equipment required for the production of munitions were selling at unusually high prices, a somewhat general belief exists that these so-called "war prices" will be materially reduced as the demand for munitions decreases.

Those who advance this theory overlook the fact that the recent increases in price of machine tools—which amount to from 25 to 50 per cent—may have been justified before the war demand existed, due to advances in the cost of the labor and material entering into machine tool manufacture, and to the increased value of investments in machine tool building plants. Bearing this in mind, machine tool users should make a careful study of the trend of prices of such equipment during the past ten or fifteen years before deciding that present prices are inflated. Allowing for the increased complexity of modern tools, it will be found that machinery builders have maintained a practically constant level for the prices of their product while facing heavy increases in the cost of production; and the only effort that has been made to meet this condition has consisted of improving the efficiency of manufacturing methods—which has only partially accomplished the purpose.

The profits made in many lines of manufacture using machine tools are far greater than those generally made by machine builders. This is due to a number of causes, among which is the policy that manufacturers in such lines have followed of advancing their selling prices whenever the cost of operating any department increased. It takes mechanics of no greater skill to make these products, but in order to market them successfully it is necessary to keep selling prices on a level that is commensurate with production costs.

The importance of this fact has been recognized by certain well-known machine tool builders who have reached the conclusion that their present selling prices were fully justified by existing industrial conditions before the outbreak of the European war and are far from being inflated. Other machinery manufacturers do not go quite so far, and concede that when the present costs of materials are reduced, a certain reduction from present selling prices may be expected. Both agree that the price level existing in the early part of 1914 was not consistent with production costs, and there is little reason to expect that any movement taking place in the near future will result in a drop to the former price level.

COOPERATION IN EXPORT TRADE[1]

METHODS EMPLOYED BY VARIOUS COUNTRIES FOR THE ADVANCEMENT AND CONTROL OF THEIR FOREIGN TRADE

IN the first three years of this century, the United States led the nations of the world in the amount of exports, but a decade later it had been displaced as leader by Great Britain, and almost surpassed by Germany. Its exports only increased from $1,410,000,000 to $2,290,000,000, or 62 per cent while Great Britain's jumped from $1,387,000,000 to $2,379,000,000, or 71 per cent, and Germany's from $1,120,000,000 to $2,155,000,000, or 92 per cent. This loss of leadership was partly due to the change in the goods the nation exported: its sales of foodstuffs decreased 13 per cent while its sales of manufactured products increased 124 per cent. Still the growth of its trade in manufactured products has not been as rapid as it might have been, because of the many restraints placed upon American trade by the cooperative methods employed by various countries for the control and development of their foreign trade.

In its report on the conditions existing in other lands the Federal Trade Commission says: "Exports are required to pay for foreign capital, services, and goods, irrespective of what locality utilizes the capital or enjoys the service." The value of foreign investments is shown by the control different countries have of the markets of South America. Railroads, street railways, light and power plants, etc. have been built largely by British capital; as a result, they are operated by men who favor British manufacturers. In many cases, the loans were made on the condition that all supplies should be bought from that nation; when this condition does not exist, the specifications are generally so fixed that none but British firms can supply the goods. One-half of the American trade to Argentine, which, in 1913, was only 15 per cent of the country's purchases abroad, consisted of goods in which foreign countries could not compete. Of the locomotives used on the railways of Argentine 75 per cent were sold by Great Britain, 20 per cent by Germany, and 2 per cent each by Belgium and the United States; while 57 per cent of the passenger and freight cars were supplied by Great Britain, 11 per cent by Germany, 19 per cent by Belgium, only 10 per cent by the United States. The activity of German capital in the promotion of electrical products resulted in 50 per cent of Argentine's imports of electrical goods being drawn from Germany, 34 per cent from Great Britain, and but 6 per cent from the United States. Through the assistance of the Deutsche Bank, which gives a bounty of $1920 to the Borsig Co. for every locomotive it sells abroad, German railway equipment has lately been sold to many of the South American state-owned railways. However, the marked increase in the use of goods of American origin, the efforts of American manufacturers to exert a larger measure of control over the distribution of their products, and the present and prospective investments of American capital in South American countries, especially in Brazil, Uruguay, and Argentine, will make a great change in the commercial relations of the American shipper and those countries.

The American exporter suffers from discrimination by railroads and vessels. Most of the European countries grant lower railroad rates to goods that will be exported than to those for domestic use. The export rate, per metric ton, for copper goods, lead in blocks, etc., between Cologne and Hamburg (a distance of 267.2 miles) in 1913, was $3.14 while the domestic rate was $6.38; the rates for machinery and machine tools were $2.52 and $4.86, respectively. Iron products, such as beams, etc. from Frankfort to Lubeck (a distance of 358.5 miles) were charged $1.79 a metric ton when exported and $5.09 when used at home. Belgium paid special attention to the development of through railway traffic to its ports from Germany, France, and Holland, and made combined railway and vessel rates.

Only 11.8 per cent of this country's water-borne exports was carried in American vessels, in 1915, and only 18.4 per cent of its imports. On the other hand, before the war, 66 per cent of the ships that entered British harbors with cargoes flew that nation's flag; one-half of Germany's foreign trade was carried in its own ships; one-half of France's exports were carried by French ships; and most of the trade of Italy and all of the trade of Norway and Sweden could be carried in their own vessels. Although Great Britain paid subsidies to ships of certain classes, less than 5 per cent of British ships received this aid; but subsidies or subventions have been freely granted by Germany, Japan, France, Italy, Austria, and Holland.

An exhaustive investigation by Congress has shown that foreign steamship companies are united in an intricate system of conferences and agreements for the purpose of stifling competition, determining sailings, fixing rates, dividing territory, alloting business, granting rebates, pooling earnings, and fighting competitors. British lines running from Canadian ports are giving preference to Canadian cargoes and receive American cargoes only when the Canadian cargoes do not fill all the available space. Besides, freight rates from Montreal to South Africa on some things are much lower than from New York to South Africa. When this difference is added to the 3 per cent preferential traffic concession granted Canadian products by the South African union, the Canadian manufacturer is given a great advantage over the American. Japanese ships also have given preference to their countrymen, with the result that thousands of tons of American freight have been piled upon the docks awaiting shipment. For some time the American consuls have been calling attention to the fact that the east coast of Africa enjoys direct connection with Europe through English, French, German, and Italian lines, while there is no direct service from America. As a result American goods suffer great delays in trans-shipment from European ports.

Many shippers claim that the foreign ship owners give the information they acquire to manufacturers of their own nationality, who at once become competitors for the future business. They also say that the steamships increase their rates whenever a nation's tariff is lowered to favor American goods, so that the American shipper gains no advantage from this reduction in the tariff. British shipping interests are also charged with deliberately trying to hamper American trade in South America by granting much lower rates on merchandise shipped from Great Britain than on similar merchandise from the United States and by not allowing enough British vessels to engage in carrying trade between the United States and South Africa. On some classes of goods, the American rates are from 30 to 40 per cent higher than the British, and the British shippers can make prompt deliveries while the Americans can not.

The ship owners, however, have the shippers completely in their power. According to the "conference agreement" of the British steamship lines running between the United States and Brazil, Uruguay and Argentine, a 10 per cent rebate on freight charges is made to all who ship only on boats of the "conference lines." These rebates, however, are paid only at six months intervals and are six months in arrears. So a shipper must prove that he has shipped only on these lines for a year, or lose all his rebates for that period. As a result, it has been impossible for independent boats to obtain cargoes, for any shipper who availed himself of these boats lost his rebates on the goods already sent.

The extent to which British bankers have helped in the development of British trade is shown by the fact that the Standard Bank of South Africa, established over fifty years ago, has 230 branches and agencies. Other British banks have nearly 150 branches and agencies throughout the country. Five of these agencies are in Abyssinia; while branches are at Leopoldville, 300 miles up the Congo;

[1] Extract from "Report on Cooperation in American Export Trade" of the Federal Trade Commission.

Zungeru, 400 miles up the Niger; Livingston, 800 miles up the Zambesi; and Khartum, 1000 miles up the Nile. Traders can find British banks in nearly any part of the world.

Since 1870 German banks have also been especially active. The charter of the Deutsche Bank, which was granted in that year, says: "The object of the company is the transaction of all sorts of banking business, particularly the fostering and facilitating of commercial relations between Germany, the European countries, and overseas markets." So widespread have become the interests of this bank that shortly before the war it was represented on the boards of 116 German and foreign concerns, some of them leading German and international cartels and combinations. France, Holland, Belgium, Portugal, Spain, Switzerland, Italy, Greece, Austria, Russia, and Japan, too, have established banks in foreign lands. Plans are now being made by Norwegian capitalists to establish a bank in New York so as to facilitate the financing of imports and exports with Scandinavia.

Commenting on the relations of the various German banks and industrial concerns, and the influence of the banks in promoting trade, a German economist says:

> The representatives of the banks on the supervisory boards of the industrial companies have always taken special care to fulfill one very effective part of the "advisory function" of the supervisory board; namely, to provide for the disposal of the products of the industrial companies in question to suitable industrial enterprises on which the banks were able to exercise some influence.

An official report from Honduras states:

> Heretofore European goods have been introduced because local importers or shipping agents have been, in reality, a combination of bank and manufacturing representatives, not making loans or financing enterprises except to secure the sale of goods produced by the manufacturers they represent.

Another advantage derived from these banks is that they supply their home offices with the ratings and characteristics of the firms and individuals of the place in which the bank is located. It is not to be expected that foreign banks will give credit information as readily to American concerns as to traders of their own nationality, except in cases where its possession results in no material stimulation of competition. The German banks have always given all possible particulars to their home office of business openings, and this information has always been available for the manufacturers and merchants in Germany. To Swiss banks is due, in large part, the growth of Swiss commerce and trade. One large Swiss bank instructs its branch managers that no business is to be transacted by which Swiss interests may be injured to the gain of foreign enterprises. Still, the value of foreign banks may be over-rated; Germany had an immense trade with Russia, in which country it had no banks, while France, which had many banks there, did comparatively little business.

The French government is especially active in the promotion of the country's foreign trade. Every department in France must have at least one chamber of commerce, which furnishes the government with information concerning industrial and commercial matters. They establish and manage various institutions, such as warehouses, permanent exhibits, departments for export information, associations for the encouragement of exports, and for locating young Frenchmen in foreign countries. In addition, the government grants bounties, subventions, and drawbacks, besides seeking the general tariff advantages by treaty.

Germany allows raw materials that are to be used in the manufacture of export goods to be admitted free of duty; also manufactured articles, in cases where it is expected to benefit German industry, that have been made from German materials and were sent abroad to be finished or improved.

In Great Britain, the Board of Trade, as it is commonly known, has the general supervision of commercial treaties, tariffs, customs duties, etc. In addition, it collects information from all available sources, which it generally publishes in its Journal, but some it gives confidentially to chambers of commerce or individual firms. For this purpose it keeps a register of all British firms desiring such information in trade openings abroad. It also has a sample room in which are shown goods competing with British products and raw materials that may be of interest to British manufacturers.

Belgium maintained a very elaborate commercial museum in which were shown samples of the products of foreign countries, both those which Belgium could export and those which it could import to advantage. It also showed samples of goods that superseded those of Belgian origin, showing why the domestic goods failed to succeed. In addition the government spent $1,000,000,000 a year as subsidies for commercial schools and industrial institutions.

Since 1896, the Japanese government has been sending agents to investigate trade conditions in other lands and has fostered the growth of its foreign trade in accordance with their reports. In order to raise the standard of Japanese goods, and thus improve their reputation, the government is now considering plans for the rigid inspection of all goods made for export.

The British Iron Trade Association was established in 1876 for the purpose of establishing communication between the members of the iron and steel trades of Great Britain upon all matters bearing upon the commercial interests of these industries. It circulates among its members detailed statistics of the trade at home and abroad and attends to matters connected with foreign tariff, commercial treaties, and home parliamentary business that may have a bearing upon the iron and steel trades. To advance the foreign trade in machinery, the British Engineers Association was organized in 1912. This association has representatives in Pekin and Petrograd. It publishes a directory of its members, in foreign languages, for the information of buyers, and selects agents in foreign countries for British firms. It also issues confidential bulletins to its members and has devised a trademark, or "chop", for use in China, where purchasers are being advised that articles bearing this chop are purely British products and that the association will aid in maintaining cordial relations. Since the beginning of the war other foreign trade associations have been formed.

As two-thirds of the German exports are manufactured articles, it was estimated seventeen years ago that one-fifth of the entire population participated directly in foreign trade. Nearly every manufacturer is a member of at least one association that is actively pushing German foreign trade. These associations give special attention to export trade, to the study of commercial treaties, tariffs, etc. The Association of German Machine Tool Manufacturers has made a study of export trade with special reference to the competition of American manufacturers and has actively opposed the trade of the latter. In addition, cartels and combinations are common and powerful; the banks have played an important part in the development of these. The Germans have published in Constantinople a daily paper, printed in both French and German, for the promotion of an interest in all things German and for the improvement of German trade in the Levant. They have educated promising young Chinese at schools and universities in Germany and established an engineering school in Shanghai, with German engineering equipment and instructors, for the training of Chinese in German engineering standards, methods, equipment, etc.

The ordinary French cartel has no central selling agency. Each member takes care of his own clientele, makes his own contracts, and ships under his own invoices; but he does this within the price and selling limitations of the agreement. The comptoir is an incorporated trading company composed exclusively of the manufacturers who turn over to it the sale of their products. Its purposes are usually the purchase from members and the sale to customers of a specified product, either in France or abroad, or both.

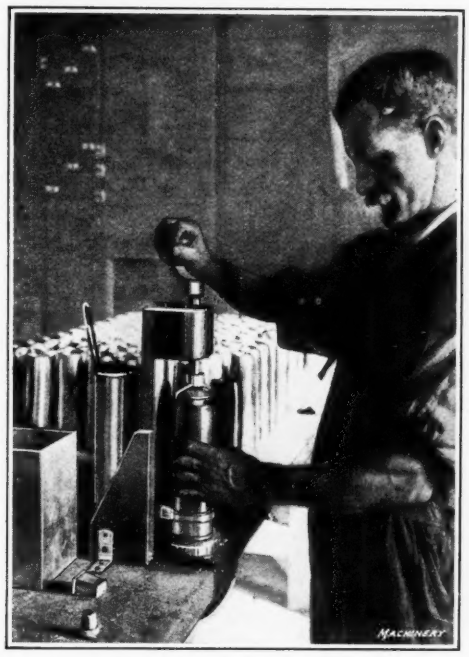
The combinations that exert the greatest influence on the American exporter, though, are those composed of buyers. The cooperative societies of Great Britain buy annually $40,000,000 worth of goods abroad. The influence of these societies, however, is beneficial rather than injurious. The metal buying combinations, on the other hand, have always exerted an adverse influence on American trade. Their ramifications are so great that they practically control the metal industry.

D. E. J.

ZINC PLUG INSERTING MACHINE

The hand-operated machine illustrated is another example of a large variety of time-saving contrivances which have had their inception in the rush of the munition business throughout this country. The final operations on a shrapnel consist of inserting a "fixing" screw in the side, screwing in the zinc plug, oiling the copper band, and packing.

The apparatus illustrated, although made largely of wood, is securely built and materially assists in reducing the time and labor on the first three operations mentioned.



Zinc Plug and Band Oiling Machine in Operation

The machine consists of a vertical shaft on the lower end of which is a large screwdriver blade and a three-pronged spider for centering the shell. As clearly shown at the upper end of this shaft there is a crank fitted with a knob for turning the shaft and screwdriver.

A circular base is furnished for the shell, which is cupped to center the shell, and can be revolved. At the rear of the machine is an oil reservoir. Protruding from the base of this reservoir, through the back of the machine onto the copper band of the shell when in place, is an oil-feeding brush. The oil saturates through this brush and distributes just the right amount to the copper band when the shell is rotated.

Three men are employed on this operation. One starts inserting the zinc plug and the small screw by hand. The second screws the zinc plug and the small screw home and oils the copper band. The third packs and boxes ready for shipment. Without attempting to make any record, these three men ordinarily pack approximately 150 shrapnel per hour. The information and illustration were secured through the courtesy of the Vermont Farm Machine Co., Bellows Falls, Vt., who developed this machine for its own use. V. B.

* * *

CATALOGUE INDEXING

With reference to the contribution by A. A. D. in the November number of MACHINERY on "Catalogue Indexing," I agree with him that catalogues could be indexed to much better advantage. Money is spent liberally for illustrations, high-class paper, several colors of ink, fancy envelopes, and everything else that might assist in eliminating every trace of "cheapness" from the catalogue, but, when the busy man gets hold of it he can't find what he wants without reading the whole book and that is too much to expect. Even purchasing agents are too busy to read all that comes in the mails. Several times I have assisted in making up indexes and have been limited by the owner or boss to one page or even less. If the manufacturer has another machine to show—a machine that looks good to him—he will put it in and cut out the index. Or, he will cut the index down to almost nothing. Before making up an index I would suggest that manufacturers look into the catalogues published by the large mail order houses. There they will find a most interesting type of complete index. Cross-indexing, bold type, small type, italics, lines, references, and everything else is used to make the index complete. Nothing is overlooked. W. F. S.

COPPER-ALUMINUM-IRON ALLOYS [1]

One of the properties which aluminum bronze possesses to a higher degree than other important bronzes is that of dissolving iron when melted and retaining this element in the solid alloy. The standard aluminum bronze made extensively for small and average castings by the Titanium Alloy Mfg. Co. contains 10 per cent aluminum and 1 per cent iron, but experiments have been made with larger amounts of iron in bronzes containing 7 to 10 per cent aluminum, inclusive. No alloys with less than 7 per cent aluminum were used, because they are too soft and weak for castings in which strength is necessary. Aluminum of 10 per cent was the higher limit adopted, because alloys containing more than this have very little ductility and are not used except where great hardness is required and brittleness is not ruinous. Alloys with over 8 per cent iron were not investigated, because of their unpromising character, judging from the other alloys tested, and also because of the difficulty of making such alloys and obtaining uniform castings. The tests consisted primarily of tensile tests on cast-to-size bars, and the Brinell hardness was determined on many of the stubs after pulling. A sufficient number of these alloys were examined with the microscope to indicate the general microstructures of all of them.

The tensile test bars were cast, in sand, about 8½ inches long and ½ inch in diameter between shoulders which were 2 inches apart. At least four bars of each alloy were tested without machining, the surfaces merely being smoothed where necessary with a fine file, so that the true average diameters could be measured with a fair degree of accuracy. Some of the bars from each heat were tested with the autographic mechanism on the testing machine, so that load-deformation curves were obtained from which the proportional limit could be read. From the other bars, the yield point was found by noting the load at which a deformation of 0.01 inch was produced on the 2-inch gage length, as measured with fine-pointed dividers. Results from test bars showing flaws or other unsoundness in their fractures were discarded unless the defect had no harmful influence on the physical properties. The hardness tests were made on cross-sections of the ends of the bars cut after they had been broken in tension. A standard Swedish Brinell machine was used for this determination, with a 10-millimeter ball, and a pressure of 500 kilograms was applied, in each case, for thirty seconds. The hardness figure was obtained from the usual table after measuring the diameter of the depression with a microscope containing a tenth-

[1] Abstract of paper by W. M. Corse and G. F. Comstock, presented at the annual meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio.

STRENGTH AND HARDNESS OF ALUMINUM-IRON BRONZE

Aluminum, Per Cent	Iron, Per Cent	Proportional Limit, Pounds per Square Inch	Yield Point, Pounds per Square Inch	Tensile Strength, Pounds per Square Inch	Elongation in 2 Inches, Per Cent	Reduction of Area, Per Cent	Hardness Number
7	1	14,300	15,700	53,200	56.0	54.2	70
7	2	17,400	18,900	63,000	39.0	35.6	70
7	3	21,300	23,300	74,500	38.0	32.2	80
7	4	22,100	23,600	76,400	38.5	35.7	89
7	5	21,600	24,700	73,600	29.0	26.9	...
7	6	21,500	25,300	77,500	31.5	27.6	...
7	8	23,600	25,600	74,600	27.5	27.6	...
8	1	16,400	19,500	57,100	45.0	43.4	70
8	2	18,200	20,600	63,800	39.0	39.2	80
8	3	24,200	26,000	81,100	36.5	32.9	109
8	4	24,800	26,300	82,100	35.0	32.0	109
9	1	18,500	23,300	69,500	43.0	35.7	77
9	2	22,400	25,800	78,300	30.5	27.4	109
9	3	25,600	28,300	81,700	26.0	26.9	109
9	4	26,400	28,500	83,000	23.0	23.8	109
10	1	19,800	24,000	77,000	24.5	25.2	94
10	2	22,800	26,700	82,600	21.0	19.2	100
10	3	26,100	28,800	86,400	20.0	20.5	109
10	4	27,400	30,000	88,600	17.0	18.5	119
10	5	29,500	33,000	80,600	12.5	16.9	...
10	6	31,000	33,500	85,500	13.0	14.7	...
10	8	31,900	35,900	86,500	11.5	12.4	...

Machinery

millimeter scale mounted in its field of view. The results of the tests are given in the accompanying table.

These tests show that for the same aluminum content there is always an increase of proportional limit, yield point and tensile strength with increasing iron content, up to 4 per cent, and, in general, a rather less substantial decrease in elongation and reduction of area. In the same way, with constant iron content, the proportional limit, yield point and tensile strength increase with increasing aluminum, while the elongation and reduction of area decrease. A study of the table shows, furthermore, that for a given strength, greater ductility can be obtained with a lower aluminum and higher iron alloy than with higher aluminum and lower iron. Thus the 8 per cent aluminum with 4 per cent iron is better in every respect than the 10 per cent aluminum with 1 per cent iron, and even the 7 per cent aluminum with 4 per cent iron is practically equal to the latter in strength, but far superior in ductility.

The excellence of the alloys with 4 per cent iron made it seem advisable to try still higher percentages, with the 7 and 10 per cent aluminum series. The difficulty of obtaining sound and homogeneous bars was not so successfully overcome with these higher percentages of iron, however, and the results were rather irregular and disappointing. Although the proportional limit and yield point increase fairly regularly with the iron content, the ultimate strength does not change much after 4 per cent iron, and the ductility drops decidedly. The best alloys, considering both strength and ductility, appear to be those containing between 3 and 4 per cent iron. With more than this there is considerable difficulty in obtaining sound and homogeneous castings, and there is only a slight gain in strength with too much decrease in ductility.

Changes in Alloys shown by Photomicrographs

It was noticed in pulling the bars with 7 and 8 per cent aluminum that those containing little iron roughen very markedly on their surfaces, so that the outlines of the crystal grains stand out prominently, some being raised above the others. With 3 per cent or more iron, however, the bars are round and smooth after testing. In the higher aluminum series, the round bars with 3 per cent or more iron have a more uniform, finer grained, and more fibrous fracture than those with less iron.

A photomicrograph shows that in the case of a 7 per cent aluminum bronze containing 1 per cent iron, the iron and aluminum are evidently in solid solution in the alpha crystals. Where the iron is increased to 4 per cent, there is a vast difference in grain size. When magnified 200 diameters, small bluish-gray crystallites, or "skeletons," are seen scattered sparingly through the yellow alpha; in an alloy with 8 per cent iron, these skeletons are well developed and much more numerous. Their composition is not known, but undoubtedly they are chiefly iron, with some aluminum, and possibly also a little copper. This constituent is the first part of the alloys to freeze, and the fine grain of the alloy with 4 per cent iron is probably caused not only by the addition of the third element, iron, to the solid solution, but also by the presence of the solid crystallites, which form many nuclei for the beginning of the crystallization. The alpha thus begins to crystallize around each little particle of the already solid iron compound, with the result that no grain can grow very large before meeting other grains which stop further growth. The alloy with 8 per cent iron does not have quite such a fine grain, doubtless because of the higher casting temperature necessary to keep the iron in solution so that the metal will remain fluid.

In the case of 10 per cent aluminum alloys with 1, 4 and 8 per cent iron, the iron crystallites do not seem to form such well developed skeletons as in the 7 per cent aluminum series, and occur either in rounded spots or in groups of spots arranged in a manner somewhat resembling clover leaves. With 10 per cent aluminum all the alloys show a duplex structure, with the dark-etching eutectoid separating the small bright alpha crystals. There is not much difference in structure between these alloys with 4 and 8 per cent iron, but both are quite different from the alloy with only 1 per cent iron, not only in respect to the presence of the black crystallites, but also in the shape and size of the alpha crystals. The addition of iron decreases their size somewhat, but the chief effect is in breaking up the Widmanstatten structure, or arrangement of elongated alpha crystals parallel with the cleavage planes of the large crystal grains.

* * *

HIGH COST OF DISCHARGING EMPLOYES

"Hiring and firing," all large employers of labor now recognize, forms the greatest leakage in modern business. In many establishments the men who do the employing have come to be known as "the fortune-tellers." It is the one place in which everything is haphazard. Magnus W. Alexander, one of the engineers of the General Electric Co., has demonstrated this great waste mathematically. Taking the employment statistics of twelve metal factories, located in six states, he has found that these places employed 37,274 persons at the beginning of the year, and 43,971 at the end. Their normal increase in employes, therefore, was 6697. Had matters worked efficiently, these factories should have employed only 6697 men—or slightly more, making due allowance for death, sickness, and other natural causes of dismissal. In reality, these factories had hired 45,571 new people. We must ponder these figures carefully to get their full significance. In order to obtain 6000 new employes, these establishments, all representative and "efficient" American concerns, had to employ 45,000! Out of seven men taken on, only one stayed. After making liberal deductions, Mr. Alexander calculates that these twelve factories employed 24,500 men and women whom they were unable to retain. Each person represented an expense ranging from $50 to $200. The companies had to keep a clerical force to hire these people and place their names on the pay-roll. They had to pay foremen and assistants to instruct them. They had to stand the expense of damaged and broken tools due to inexperience. The reduced rate of production represented another positive loss, and then there was the spoiled work which "new hands" turn out in such abundance. Mr. Alexander takes the lowest estimate, $50 per man, as representing this loss. At this rate, "hiring and firing" caused a waste in these factories of nearly $1,000,000 a year. At the highest estimate, $200, the practice resulted in a waste of $4,000,000.—*Harper's Magazine.*

* * *

It is said that statistics show that 84 per cent of the business failures of the country are merchants who did not advertise.

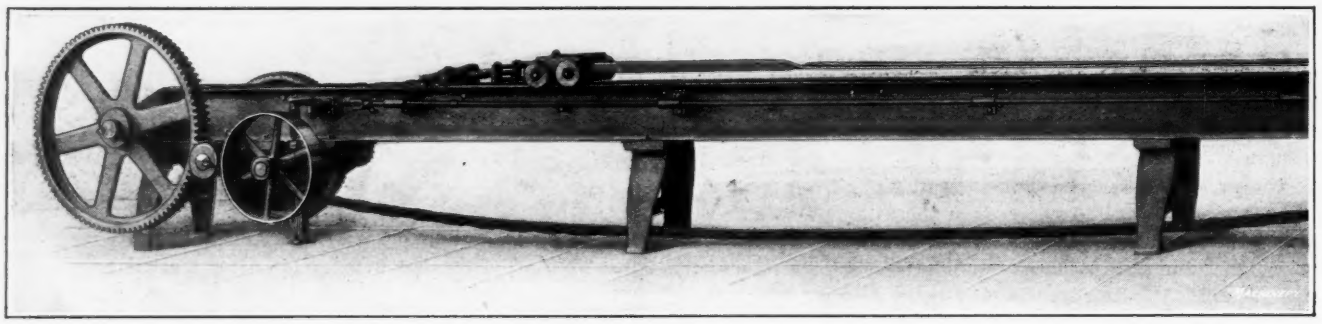


Fig. 1. Draw-bench of Typical Design built by the Loy & Nawrath Co., Newark, N. J., for Use in the Manufacture of Cold-drawn

MAKING COLD-DRAWN STEEL SECTIONS

EQUIPMENT FOR PRODUCING A VARIETY OF SHAPES FROM STRIP STEEL

BY EDWARD K. HAMMOND [1]

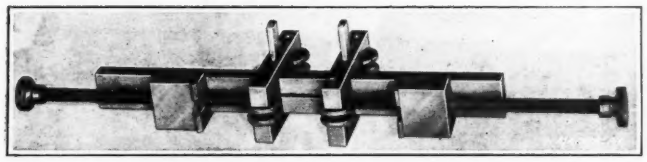
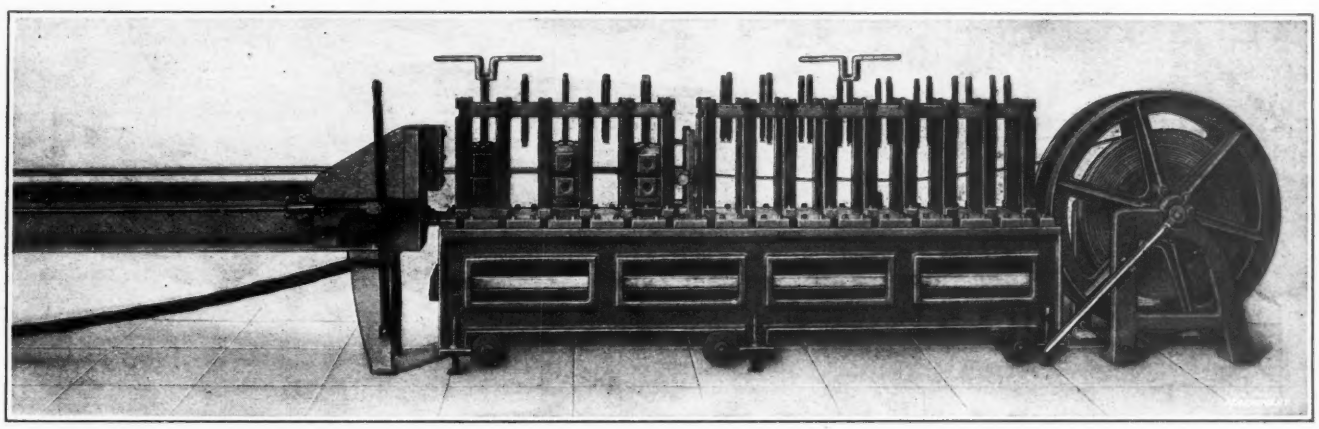


Fig. 2. Stock Guide, showing Means of Adjustment for Strips of Different Width

IN the construction of fireproof buildings, steel Pullman cars, etc., door moldings, chair rails, picture molding and similar trim are made of cold-drawn steel sections. Despite the similarity of names, these differ greatly from I-beams, channels, tees, etc., commonly known as "steel sections," both as regards form and method of manufacture. Structural steel sections are rolled out from hot billets, and the material is carried through the mill by the tractive action of the rolls which are driven by power. Cold-drawn steel sections are also made by bringing the material into the desired form by passing it between a series of rolls; but in this case the rolls are loose on their studs, and the material is drawn through them by the standard form of draw-bench used for wire drawing and similar operations. As in the case of hot-rolling, the rolls used for cold-drawing are grooved progressively so that the steel is gradually brought to the required form, but in cold-drawing the start is made from a strip of cold-drawn steel, and neither the thickness nor length changes materially during the entire operation, the only change consisting of gradually bending it into the required form. The Loy & Nawrath Co., 21-29 Runyon St., Newark, N. J., makes a specialty of building equipment for making cold-drawn steel sections and we are indebted to this company for the information presented in this article.

The type of draw-bench used in making cold-drawn steel sections is of practically standard design and does not require description. At the head of the bench is placed what is known as a roll head, in which are mounted the series of rolls used to bring the flat strip of sheet steel to the desired form. The rolls in this head are arranged in pairs, and the number of pairs necessary to complete the forming operation depends upon the complexity of the drawn steel section to be produced. The more complex the section, the greater will be the number of rolls required; but in any case, the section is completely formed before leaving the last pair of rolls. However, the general statement may be made that from one to eight pairs of rolls are required. In each pair both the lower and upper rolls are made adjustable, the vertical position of the upper roll in relation to the lower roll being governed by screws actuated by a handwheel located at the top of the head. As in ordinary rolling mill practice, the depth of the grooves in the rolls increases progressively; and it is important to have sufficient space between successive pairs of rolls in order that the metal may have time to flow easily into the new shape imposed upon it by each new pair of rolls.

The scope of this process is shown by Fig. 4, which illustrates a variety of cold-drawn steel sections. It will be seen that the forms produced vary from simple channels, vees, etc., to quite complicated sections, in many of which the two edges of the flat strip steel have been brought together to form a butt joint. When considerable strength is required or when the appearance of the product in which cold-drawn sections are used is of considerable importance, it is customary to weld the seam with an oxy-acetylene welding outfit, and when so desired the weld can be ground smooth so that the metal can be enameled, painted or given any other form of finish. In making cold-drawn steel sections, a circular swing saw is used in connection with the draw-bench. This saw is mounted at the rear end of the roll head and provides for cutting off the length of steel which has just been drawn through the rolls. The length of sections varies from 20 to 100 feet, according to the purpose for which they are intended, but in any case the steel is pulled along until the dog on the draw-bench comes opposite a gage mark; then the drawing operation is stopped and the swing saw is pulled down and cuts off the finished length of steel. The steel is under tension and a slight cut causes it to break before the saw completes the cut.



Steel Sections. The Draw-bench is equipped with Roll Head and other Special Features required for handling and forming Strip Stock

In starting work, a coil of flat cold-rolled strip steel is mounted on a reel at the head of the machine, and the end of this stock is passed between the rolls and gripped by the tongs or gripping jaws, on the draw-bench, the upper roll of each pair being raised sufficiently to allow the flat steel to pass through. The adjustable roll of the first pair is then screwed down to bend the steel to the form of these rolls. Having proceeded to this point, the steel is pulled for a sufficient distance to bring the formed section between the second pair of rolls. The draw-bench is then stopped and the adjustable roll

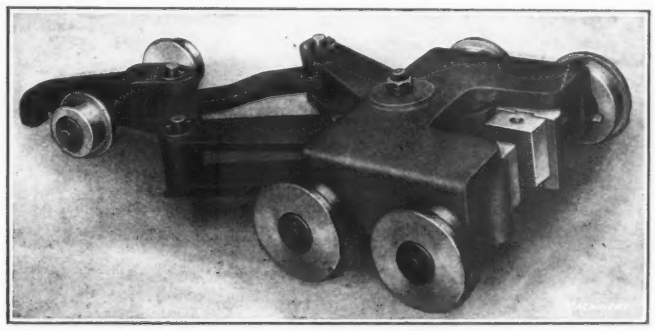


Fig. 3. Dog with Toggle-operated Jaws to grip Stock and pull it through Roll Head

[1] Associate Editor of MACHINERY.

of the second pair is screwed down to bend the sheet steel to the form of that pair of rolls. After this has been done, the draw-bench is again started and the steel is pulled along until the section formed by the second pair of rolls comes into position between the third pair, when the draw-bench is stopped and the upper roll of the third pair is forced down to make the metal take the form of this pair of rolls. Regardless of the number of pairs of rolls required to complete the rolling operation, this process must be carried on until all the rolls in the head have been screwed down one after the other; and then the machine is ready to start drawing steel of the required form. The stock passes through an oil bath before entering the roll head, and carries sufficient oil with it to thoroughly lubricate the rolls. Fig. 5 shows a set of three rolls for drawing a section of the form shown in Fig. 8, the latter illustration showing quite clearly the manner in which the steel is gradually brought to the desired form. The rolls illustrated in Figs. 5 and 6 were mounted side by side to show them more clearly, but they are not mounted in this way in the roll head; the method actually used is clearly shown in Figs. 1 and 7.

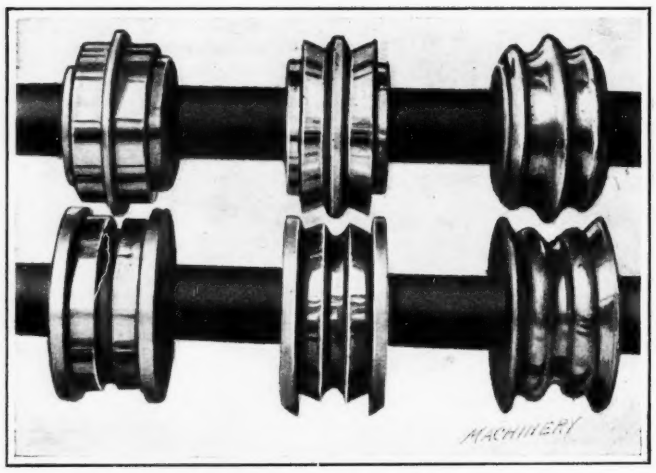


Fig. 6. Another Example of a Set of Three Pairs of Rolls

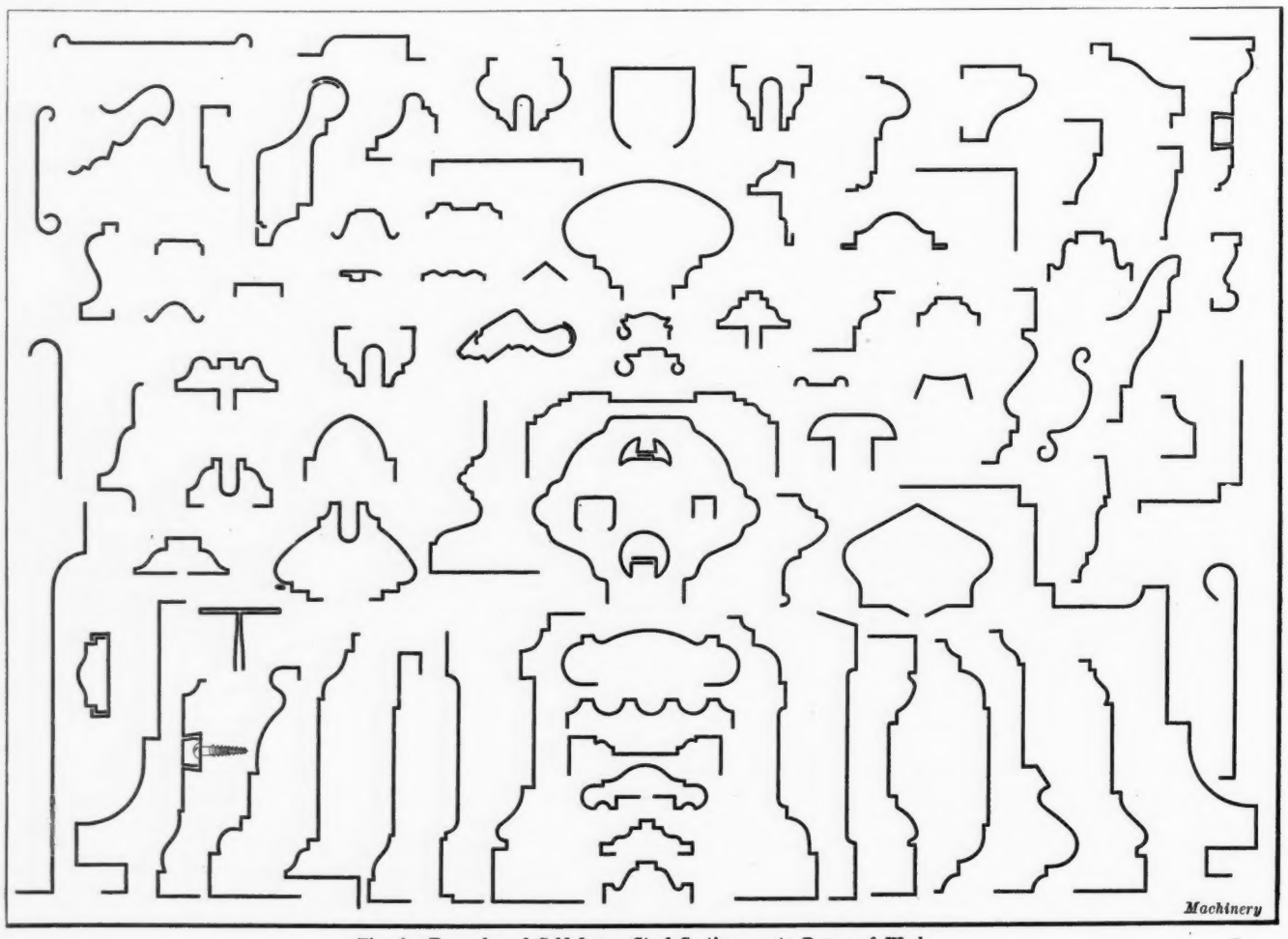


Fig. 4. Examples of Cold-drawn Steel Sections—note Range of Work

In preparing the roll head for operation, from four to ten feet of stock will be wasted while the rolls are being screwed down; and as the average length of a commercial roll of strip steel is about 150 feet, it will be obvious that the wasting of this amount of material would be entirely out of the question. To avoid loss from this cause, the expedient has been adpoted of using an oxy-acetylene welding outfit for butt-welding the beginning of a new coil of steel onto the end of a coil which has been almost drawn through the roll head. As practically any number of coils can be handled in this way, the loss of material involved in starting the machine is negligible; and on this account, when it is desired to start work on another job in shops which use a single draw-bench for drawing a number of different forms, it is found worth while to leave the end of a coil of steel in place between the rolls and replace the entire roll head with a new head equipped with rolls of the desired form. In this way, the old head may be put back in place, a fresh coil of steel welded to the piece that was left between the rolls, and the process of drawing started again without the loss of any material. When several heads are used in this way, they are mounted on wheels to facilitate handling.

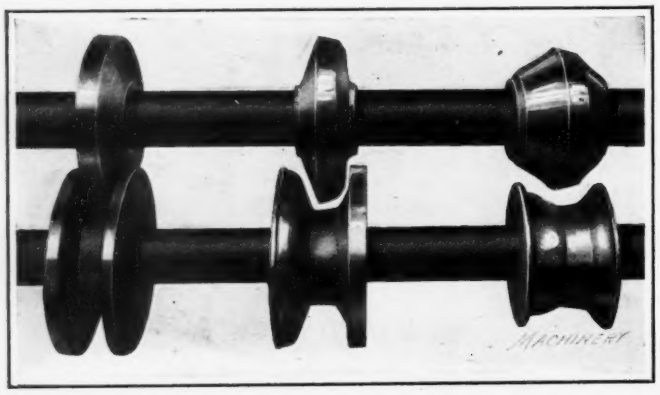


Fig. 5. Set of Three Pairs of Rolls for drawing Section shown in Fig. 8

It was mentioned that from four to ten feet of steel is lost

in the form of scrap while setting up the machine for any given drawing operation. This loss is unimportant because it only occurs at the beginning of the operation, after which the draw-bench can be run without further loss from this cause. But there is one other source of loss which cannot be avoided, *i. e.*, the amount of metal which goes into the scrap pile through the crushing of the front end of each length of cold-drawn steel by the gripping jaws on the draw-bench. About 6 inches of stock is lost from this cause on each "draw," and the percentage of loss naturally varies according to the length of the pieces being drawn, but the average will be about 1.66 per cent. During the drawing operation, however, the length of the metal is somewhat increased and this elongation just about offsets the loss due to crushing the end of each length by the clamp on the draw-bench.

Cold-drawn steel sections are commonly made in lengths of 20, 30 and 100 feet, although the 30-foot lengths are by far the most common. Drawing sections of more than this length is unsatisfactory for two reasons: first, longer pieces have

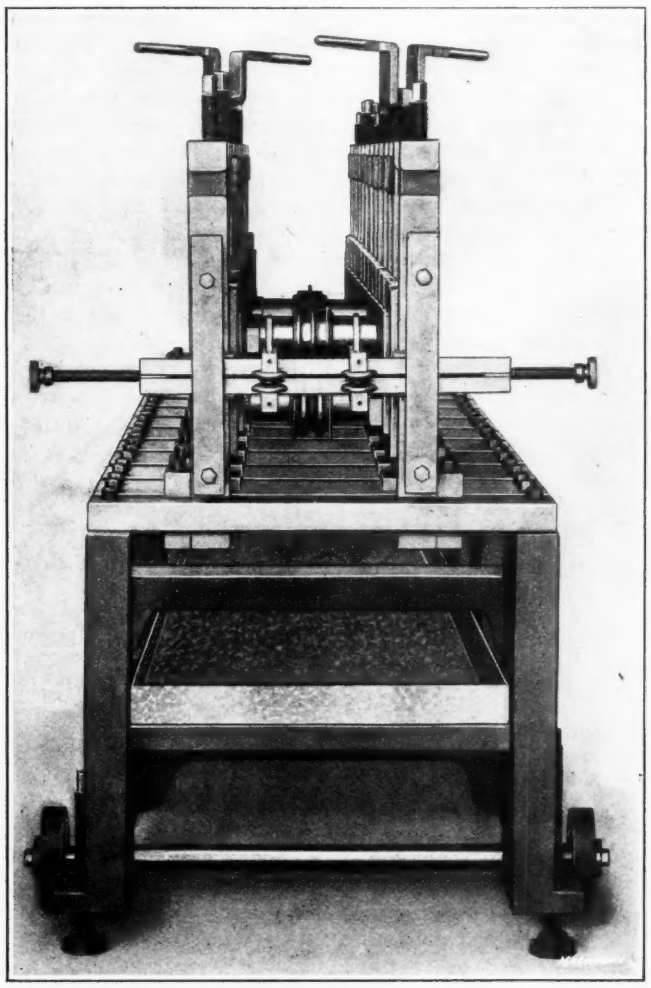


Fig. 7. End View of Roll Head, showing Arrangement of Guide and Rolls

a tendency to twist; and second, pieces of more than 30 feet in length are inconvenient to handle. It is difficult to place a limit on the scope of this process, but up to the present time the maximum width of cold-drawn strip steel which the Loy & Nawrath Co. has drawn in this way is 16 inches, and 10 gage is the maximum thickness of stock for which machines have been built.

* * *

BRASS AND BRONZE DIE-CASTINGS

At the beginning of 1913, all die-castings produced commercially were composed of either tin, lead, or zinc base alloys, and about 90 per cent were of the latter type. Because of the many limitations to the universal application of die-castings made from these alloys, the Doehler Die-Casting Co. of Brooklyn, N. Y., began a series of experiments having for their object the improvement and extended application of the die-casting. Their research was divided into four branches: improvement of the zinc alloys then in use, elimination of air holes, the die-casting of aluminum and aluminum alloys, and the die-casting of brasses and bronzes.

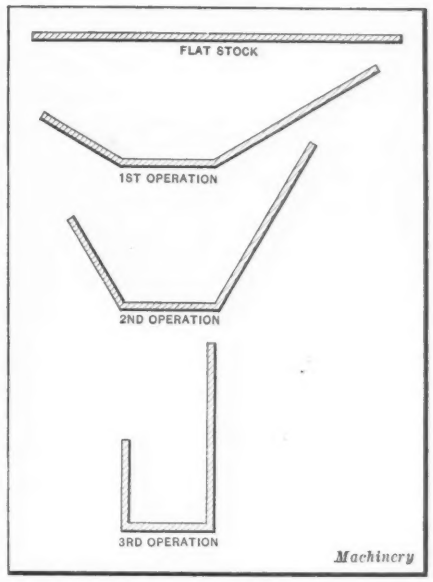


Fig. 8. Condition of Work after passing through Successive Pairs of Rolls

During the infancy of the die-casting industry very little attention was paid to the metallurgical phase of the process; alloys were mixed without regard to metallurgical principles. The chemical and physical testing of the raw materials entering into the alloys, or of the mixed alloys, was not dreamed of, nor was there any systematic control of temperature during mixing or casting. To the fact that these conditions still exist in die-casting plants must be attributed the serious difficulties that so many manufacturers have met in their attempts to use die-cast products.

It is well known, although reluctantly admitted by some manufacturers, that die-castings cannot be made as solid as sand castings. The reason for this is very simple. Die-castings are made by forcing metal into a steel mold under high pressure, and the steel mold, unlike the sand mold, does not allow the air to pass through it. The metal chills almost instantaneously in the metal mold, trapping air unless suitable vents are allowed in the die. Announcements have been made at various times that some manufacturer has devised a new process of die-casting whereby air holes are entirely eliminated. The manufacturer who publishes any statement of this kind is either guilty of an attempt to fool the consumer or lacks knowledge of the fundamental principles involved in the process of die-casting. Every part has its individual shape and requires individual attention and study. By careful and concentrated attention on some parts, the gates and vents may be so located as to insure a solid casting. Only by a careful study of the gating and venting of every individual die can a casting of maximum density be obtained. No die-casting process can be said to produce solid castings simply because a higher pressure or "vacuum pressure" is used. As a matter of fact, there are many cases in die-casting practice where low pressures will produce denser castings; also many cases where a vacuum is a decided disadvantage.

The Doehler Die-Casting Co. has developed a new process for die-casting brass and bronze from the experimental to the commercial stage. The process is not limited to any particular alloy; in fact, yellow brass, red brass, phosphor-bronze, aluminum bronze and manganese bronze can be die-cast. The castings are said to be solid and free from air holes of any kind. The claim is not made that all parts now cast in white metal can be die-cast in brass economically, but that brass die-castings are now a commercial possibility.

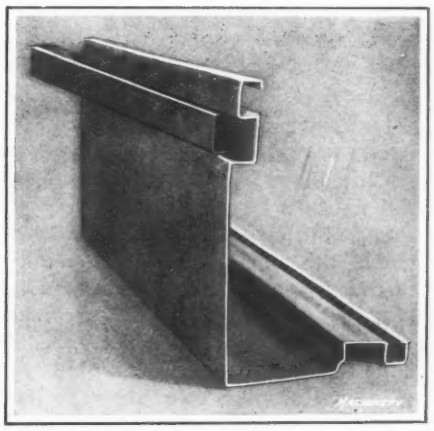


Fig. 9. Cold-drawn Steel Section in which Screws or Rivets are concealed by Insert

ALUMINUM CASTINGS AND FORGINGS[1]

In the manufacture of light castings the most desirable properties are: Low specific gravity, a fair amount of strength and freedom from brittleness, good machining properties, maximum resistance to corrosion, good casting qualities, and freedom from hot-shortness. As pure aluminum is entirely too soft to produce satisfactory castings for most purposes, it is alloyed with some element, usually 8 per cent copper. Zinc and tin are also frequently used. The addition of from 8 to 10 per cent of hardener, however, increases the specific gravity; besides, the hardened metal has a strong tendency to brittleness, and in most cases is less resistant to corrosion than either of the component metals. In the case of intricate castings, hot-shortness is another feature. The use of manganese in relatively small quantities, however, hardens and strengthens the alloy without destroying its ductility. The machining properties are excellent, and the specific gravity of the finished alloy is from 0.35 to 0.40 less than that of the ordinary No. 8 alloy. When properly made, these alloys are practically free from hot-shortness, and the most intricate castings can be produced with comparative ease.

The most dangerous impurities in aluminum alloys are carbon, silicon and iron. To prevent the introduction of these, either in the metal used or through the medium of crucibles and tools, carbonless manganese produced by the thermit process has been used exclusively. This manganese is alloyed with copper, when aluminum-copper-manganese is being made, by melting 60 per cent copper and introducing 40 per cent manganese in small pieces and heating until the two metals have combined, which is shown by the smooth condition of the surface of the metal. This alloy can then be diluted with an equal weight of aluminum, although it is feasible to use copper-manganese direct. In making the alloy of manganese without copper, 80 per cent aluminum is melted and brought to a bright cherry red; then 20 per cent manganese is added in very small pieces. The alloy should be poured as soon as all the manganese is dissolved.

In melting aluminum alloys, clay or clay-lined crucibles are preferable. No charcoal or carbonaceous covering is used, as carbon combines with this alloy, forming a very brittle compound. Gates and sprues from castings must be carefully cleaned and freed from sand, as practically all the sand introduced into the pot is reduced to silicon, which materially weakens the alloy. When there is danger of introducing sand into the crucible, a flux made by melting together 60 per cent potassium chloride and 40 per cent kryolite, powdered, may be used.

In preparing the alloy for casting purposes, the hardening substance is placed in a crucible that is brought to a bright red heat, and is melted as quickly as possible. The draft is then cut down and aluminum is added in small amounts as fast as it will melt, the temperature of the mixture being kept at a faint red heat. The crucible is drawn from the furnace just before the last of the aluminum is melted to prevent the metal becoming overheated. Overheated aluminum will absorb silica from the walls of the crucible, and when once overheated, the aluminum is practically worthless. Just before pouring, ¼ ounce zinc chloride is added to the contents of the crucible, and the metal is stirred with a clay-covered skimmer. This zinc salt tends to reduce the oxides and dross in the metal and produces an ideal condition for casting purposes. Alloys of aluminum containing manganese have a slightly greater shrinkage than those containing copper alone, and due allowance must be made by using ample risers and chill plates on intricate castings.

Tests of sand-cast aluminum castings taken at random heats showed the results given in the accompanying table. The aluminum was composed of manganese, 1.5 per cent; copper, 2 per cent; and aluminum, 96 per cent.

The elastic ratio of this alloy, as determined by the drop of the beam of the testing machine, will average about 60 per cent of the ultimate strength. The fracture of test specimens is silky and shows considerable toughness, instead of being granular and brittle, as is the case with many aluminum alloys. Castings are practically free from hot-shortness. Aluminum containing manganese will work very freely either by cold-rolling or hot-forging, and many intricate shaped drop-forgings have been produced.

RESULTS OF TESTS ON SAND-CAST ALUMINUM CASTINGS

Tensile Strength, Pounds per Square Inch	Per Cent Elongation in 2 Inches	Tensile Strength, Pounds per Square Inch	Per Cent Elongation in 2 Inches
22,000	15.0	21,000	13.0
22,000	14.0	22,000	12.0
21,000	8.0	24,000	10.0
19,000	9.5	19,000	12.0
19,000	14.7	18,000	13.0
19,000	14.0	.....	....

Machinery

For forging, the metal is as carefully prepared as for casting. The ingot mold is the same type as is used for bronze. These molds are heated to about 500 degrees F. and given a thin coating of orange shellac to produce a clean skin. The metal should be carefully skimmed and poured very quickly in order to prevent cold-shuts. In making drop-forgings, a little preliminary forging is desirable. The ingot can be cut or cropped to the desired lengths and forged to approximate shape at a temperature of from 1150 to 1400 degrees F., after which it can be finished in the dies. Dies of the type used for tobin bronze are perfectly satisfactory for aluminum work. The stiffness and strength of the forged material can be controlled by varying the finishing temperature. Considerable stiffness and elasticity can be imparted to the forgings by two or three blows of the forging dies at about 500 degrees F.

The physical properties of a bar forged to one inch square and turned to standard size tensile specimens, when composed of manganese, 1 per cent, copper, 2 per cent, and aluminum, 96.5 per cent, are as follows:

	Tensile Strength	Yield Point	Per Cent Elongation	Per Cent Reduction of Area
Cold-finished	27,750	27,750	12.0	47.0
Hot-finished	21,083	12,223	26.7	48.7
Intermediate	25,617	22,918	17.4	52.0

In the case of a hard alloy containing manganese, 2 per cent, copper, 3 per cent, and aluminum, 94.5 per cent, the physical properties are:

	Tensile Strength	Yield Point	Per Cent Elongation	Per Cent Reduction of Area
Cold-finished	31,930	30,000	9.75	35.30
Cold-finished	34,123	33,000	4.00	11.25
Cold-finished	30,405	30,000	11.25	30.78
Hot-finished	27,450	15,000	21.95	56.00
Intermediate	28,670	22,000	21.00	50.40

Sections cut from thin drop-forgings that were cold-finished have shown a tensile strength as high as 40,000 pounds per square inch. The forged material machines well and shows a fine silky fracture when broken. The increased density of the metal produced by forging makes it a great deal more resistant to sea-water corrosion than the cast alloy. Several drop-forgings of these alloys are now undergoing service tests on ships at sea to determine their resistance to corrosion, and reports thus far received are very promising. Considering the low specific gravity of these alloys, together with the strength and ductility obtainable, the material compares favorably with the heavier bronze and brass forging materials for many purposes.

* * *

In the building of the new open-hearth furnace at Vereeniging, Transvaal, South Africa, homemade products are being used almost exclusively. This furnace is to turn out 1000 tons of steel a month, or twice as much as the furnace it replaces. The magnesite and silica brick are made locally, and all castings, except the valves and chains, are made on the spot; the chrome ore hearth is made from Rhodesian material; the gas required to melt the charges will be made from local bituminous coal. At present, the foundry is working on scrap; but it is claimed that deposits of high-class iron ore lie within a few miles of the foundry.

[1] Abstract of paper by P. E. McKinney, read at the annual meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio.

THEORY OF ENLARGED HERRINGBONE PINIONS

FORMULAS FOR DESIGNING PINIONS TO AVOID UNDER-CUT

BY E. W. MILLER [1]

IT is common to make the diameter of herringbone pinions having less than twenty teeth somewhat larger than the size indicated by the pitch and number of teeth. Some authorities advocate enlarging all pinions with less than twenty-five teeth. The object is to avoid under-cut, thereby insuring strong teeth and a maximum of involute tooth surface. Under-cutting is caused by interference of the generating tool with the teeth of the pinion being cut. The most pronounced case of interference is that caused by an unmodified hob or any other tool corresponding to a rack. Formulas for determining these pinion diameters have been set forth, and at least two are in use today. Apparently they have been determined empirically. The logical procedure is to derive a formula which will determine mathematically the necessary amount of enlargement and adhere to this figure. Any further increase is useless and may result in an excessive pressure angle.

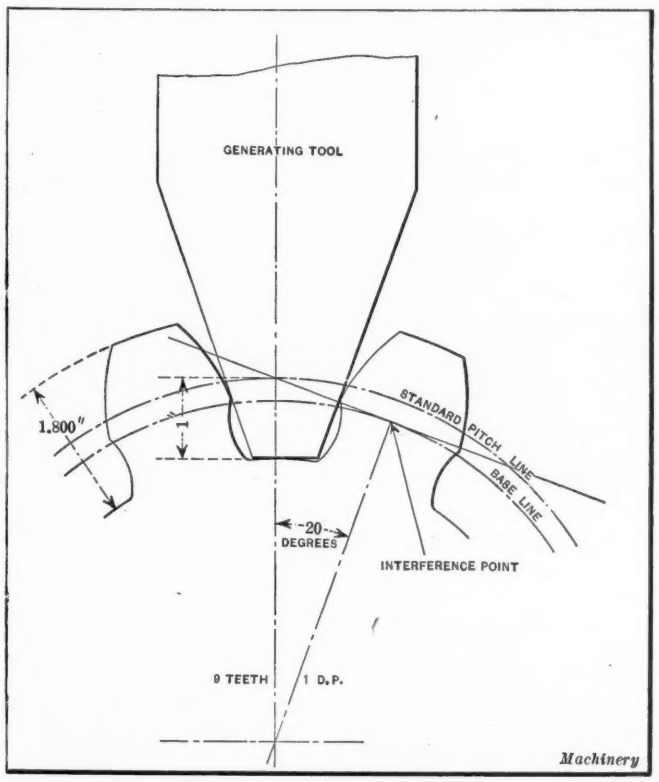


Fig. 1. Extreme Case of Interference between Rack Tool and Nine-tooth Pinion

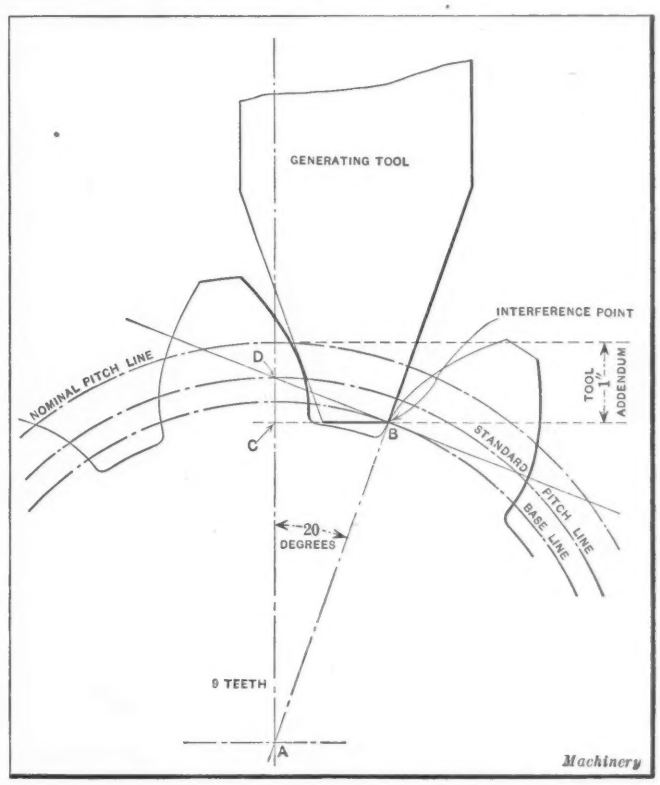


Fig. 2. Enlarged Pinion in which Interference between Tool and Teeth has been overcome

In Fig. 1 is shown the extreme case of interference of a rack tool with a nine-tooth pinion. The tooth addendum is 0.8, dedendum 0.8, clearance 0.2, making a total depth of 1.8 inch. The distance from the pitch line to the bottom of the space is 1 inch, pressure angle, 20 degrees, and diametral pitch, 1. By diametral pitch is meant the pitch as measured in a plane at right angles to the axis of the gear. It should be distinguished from the normal pitch, which is measured in a plane normal to the helix angle. These planes may be referred to as the diametral plane and normal plane. The action of a pair of helical gears operating on parallel axes is identical to that of spur gears. This action should therefore be studied from the diametral plane, and is so considered in Fig. 1. It is to be noted that the end of the generating tool falls well inside the interference point, thus resulting in under-cut, weakened teeth and a shortened involute surface. In Fig. 2 the pinion has been enlarged until the cutting tool just reaches the interference point. No under-cutting occurs and the involute curve comes clear down to the base line. The pitch radius AD multiplied by cosine 20 degrees gives the base line radius AB; and cosine 20 degrees multiplied by AB determines the length AC. Obviously, if the tool addendum of 1 inch be added to AC, the nominal pitch radius is obtained; and this value multiplied by 2 gives the nominal pitch diameter. Formula (1), developed from the preceding considerations, determines the exact amount of enlargement required of the pinion to avoid interference and consequent under-cutting of the teeth.

[1] Chief Engineer, Fellows Gear Shaper Co., Springfield, Vt.

Suggested Formula

$$\frac{\text{Number of teeth}}{\text{Diametral pitch}}(\cos \text{pressure angle})^2 + \frac{2}{\text{Diametral pitch}} = \text{Nominal pitch diameter.} \quad (1)$$

Formulas Now in Use

$$\text{Pitch diameter (under 25 teeth)} = \frac{(0.96 \times \text{number teeth}) + 1}{\text{Diametral pitch}} \quad (2)$$

$$\text{Pitch diameter (under 20 teeth)} = \frac{(0.95 \times \text{number teeth}) + 1}{\text{Diametral pitch}} \quad (3)$$

NOMINAL PITCH DIAMETERS IN INCHES OBTAINED FROM FORMULAS (1), (2) AND (3)[1]

No. of Teeth	9	10	11	12	13	14	15	16	17	18
Formula 1	9.947	10.830	11.713	12.596	13.479	14.362	15.245	16.128	17.011	17.894
Formula 2	9.640	10.600	11.560	12.520	13.480	14.440	15.400	16.360	17.320	18.280
Formula 3	9.550	10.500	11.450	12.400	13.350	14.300	15.250	16.200	17.150	18.100

Machinery

[1] Note: Diametral pitch, 1; pressure angle, 20 degrees; tooth depth, 1.8 inch.

The table gives nominal pitch diameters obtained by applying the three different formulas to pinions with from nine to eighteen teeth, inclusive. The newly suggested Formula (1) gives the greatest diameters for pinions

with less than thirteen teeth. At thirteen teeth, Formula (2) comes to the front with Formula (1) in second place. At fifteen teeth, Formula (2) indicates the greatest increase and Formula (1) the least. If it is conceded that Formula (1) is correct, the following comparison of Formulas (2) and (3) is of interest. For less than fourteen teeth, Formula (2) is nearer right; for fourteen teeth or more, Formula (3) is more accurate. It is noteworthy that at eighteen teeth no enlargement is necessary, as the size 17.894 inches is smaller than the standard pitch diameter. Herringbone pinions with less than fifteen teeth are rarely used, since long service is a requirement. This factor determines the minimum number of teeth, which is perhaps fortunate, since the greater increase in nominal pitch diameters of smaller pinions would result in excessive pressure angles. With fifteen teeth as the limit, we are spared this problem, the solution of which is at best a compromise of under-cut and pressure angle.

Formula (2) is apparently based on results obtained in using a hob with an axial pressure angle of 20 degrees. In this case the hob axis is perpendicular to the axis of the gear it is cutting. The hob lead angle is the complement of that of the gear being produced. This arrangement surely results in producing gears of 20 degrees pressure angle. The fact remains that many gears are being cut with the hob set at an angle corresponding to the helix angle of the gear plus or minus the hob lead angle, as the case requires. Usually the hob tooth angle, as measured in the normal plane, is 20 degrees. While the use of great helix angles is to be deplored, herringbone gears are in use with helix angles as high as 35 and even

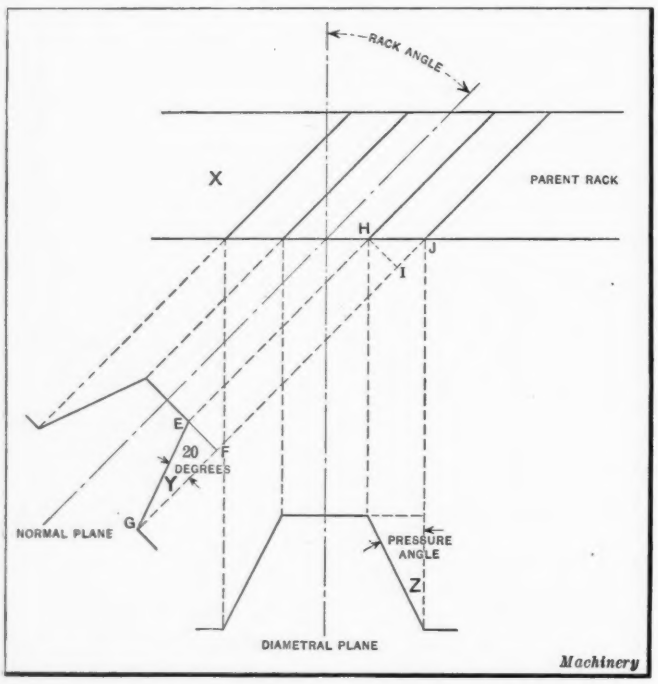


Fig. 3. Diagram showing Relation between Helix and Pressure Angles

45 degrees. There is a definite relation between the helix and pressure angles of a helical gear, and Fig. 3 illustrates this point. Let *X* be a parent rack from which helical gears may be developed. At *Y* is shown the end of the teeth as viewed in the normal plane, the angle of the tooth side being 20 degrees. A development of this tooth at *Z* in a plane perpendicular to the side of the rack shows graphically that tooth angle *Z* is greater than *Y*.

$$EF = \text{Tan 20 degrees} \times GF = HI$$

$$\frac{HI}{\text{Cos rack angle}} = HJ$$

$$HJ = \tan Z$$

$$\frac{\text{Tan normal angle}}{\text{Cos helix angle}} = \text{tan pressure angle}$$

Using the preceding formula, we find that a 20-degree generating tool cuts a 23-degree helix angle gear with a pressure angle 21 degrees, 36 minutes, and a 45-degree helix angle gear with a pressure angle of 27 degrees, 14 minutes. These two

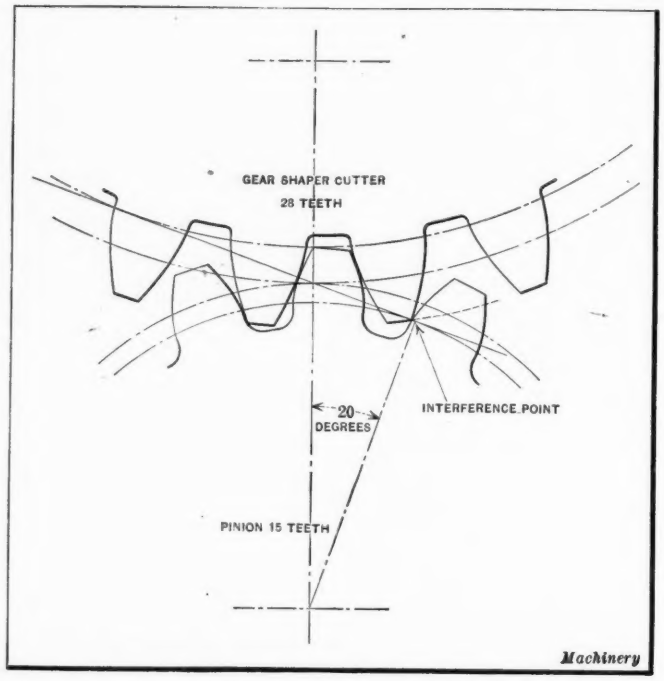


Fig. 4. Freedom from Interference when generating Teeth on Fellows Gear Shaper

cases are given to illustrate the great pressure angle difference. From the foregoing, two sound reasons may be advanced for the adoption of Formula (1): First, the exact amount of enlargement to accomplish the desired end is easily determined; second, the pressure angle, a very important factor in the matter of under-cut, is taken into consideration.

When cutting helical pinions by a certain process, namely, that of the Fellows Gear Shaper Co., Springfield, Vt., no enlargement is necessary. The cutter does not interfere with a fifteen-tooth pinion, a fact which is evidenced by Fig. 4. We have referred to the standard pitch diameter, which is understood to be obtained by dividing the number of teeth by the pitch; also to the nominal pitch diameter which exceeds the standard by the amount of enlargement. In action, an enlarged pinion never runs with the mating gear at its nominal pitch diameter unless the mating gear is given an equal percentage of enlargement; and it never runs with the mating gear at its standard diameter unless standard center distance is maintained.

Fig. 5 shows a fifteen-tooth pinion and a forty-five-tooth gear

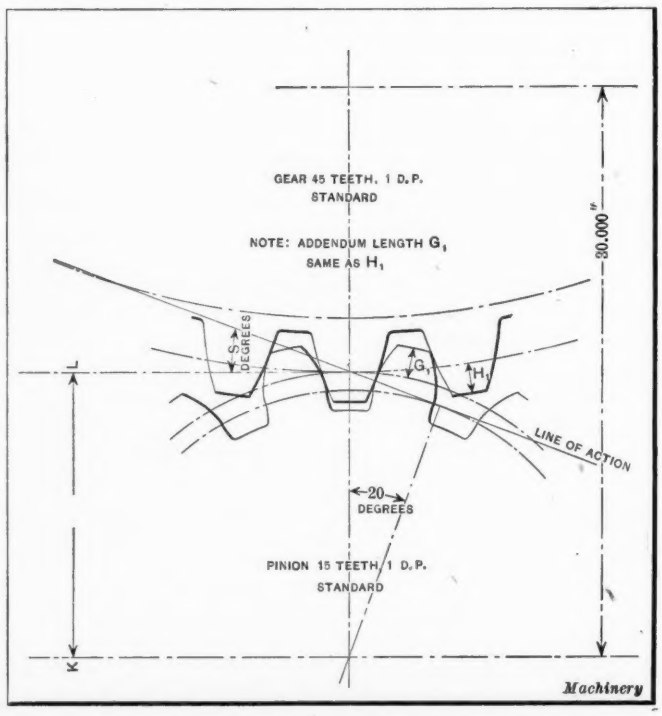


Fig. 5. Pinion with Fifteen Teeth and Gear with Forty-five Teeth generated by Rack Tool and in Engagement at Standard Center Distance of 30 Inches

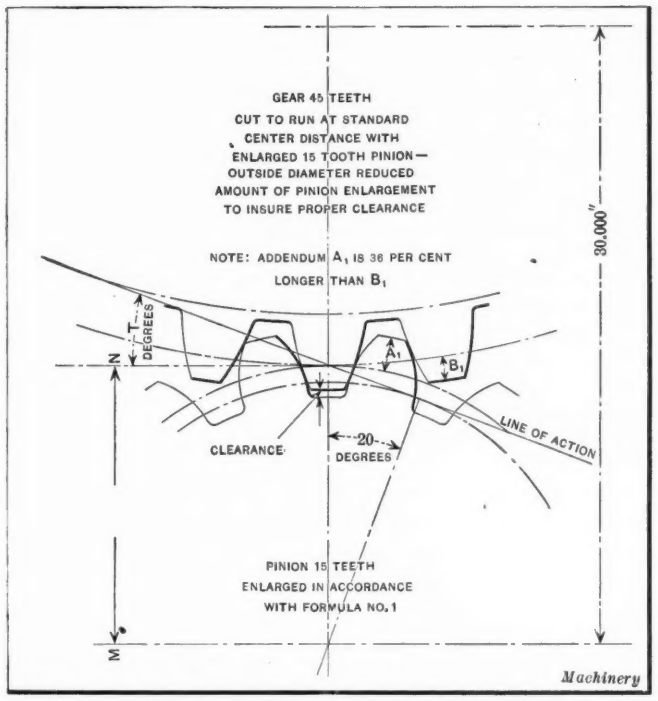


Fig. 6. Pinion enlarged according to Formula (1) engages Gear properly at Standard Center Distance of 30 Inches

of 1 diametral pitch, both of which have been generated from a rack tool and are in engagement at a standard center distance of 30 inches. In Fig. 6 a pinion enlarged according to Formula (1) is engaging the gear snugly at a standard center distance of 30 inches. The gear has, of course, been somewhat reduced. Fig. 7 shows an enlarged pinion running with a standard gear at a center distance of 30.122 inches, the standard center distance having been increased one-half the amount of pinion enlargement. In Fig. 8, the gear has a percentage of enlargement equal to that of the pinion and the center distance of 30.490 inches is greater than standard by exactly one-half the sum of gear and pinion increase. In each of the last four illustrations, a line tangent to pinion and gear base circles crosses the line of centers. This is the line of action. The intersections of various lines of action with center lines are measured from the pinion centers by lines *KL*, *MN*, *OP* and *QR*. Distances *KL* and *MN* are equal; *OP* is greater and *QR* is greatest. Angles *S* and *T* are equal; *U* is greater and *V* is greatest. The intersections are pitch points and the circles passing through them are the pitch line of the gears as they run together or the actual pitch lines. The angles of the lines of action are the actual pressure angles. It is evident from this that the actual pressure angle is dependent upon the center distance at which the gears run and independent of the enlargement. Mathematically, the actual pitch diameter, diametral pitch and pressure angle may be determined by the following formulas:

$$\text{Actual pitch diameter of Pinion} = \frac{\text{Center distance} \times 2 \times \text{number of teeth in pinion}}{\text{Sum of teeth in gear and pinion}}$$

$$\text{Actual pitch diameter of Gear} = \frac{\text{Center distance} \times 2 \times \text{number of teeth in gear}}{\text{Sum of teeth in gear and pinion}}$$

$$\text{Cos actual pressure angle} = \frac{\text{Base line diameter}}{\text{Actual pitch diameter}}$$

$$\text{Actual diametral pitch} = \frac{\text{Number of teeth}}{\text{Actual pitch diameter}}$$

A study of the four diagrams, Figs. 5, 6, 7 and 8, makes plain that in Figs. 5 and 8 the addendum circles of gear and pinion are greater than their respective actual pitch circles by equal amounts. This is not true in Figs. 6 and 7. At the

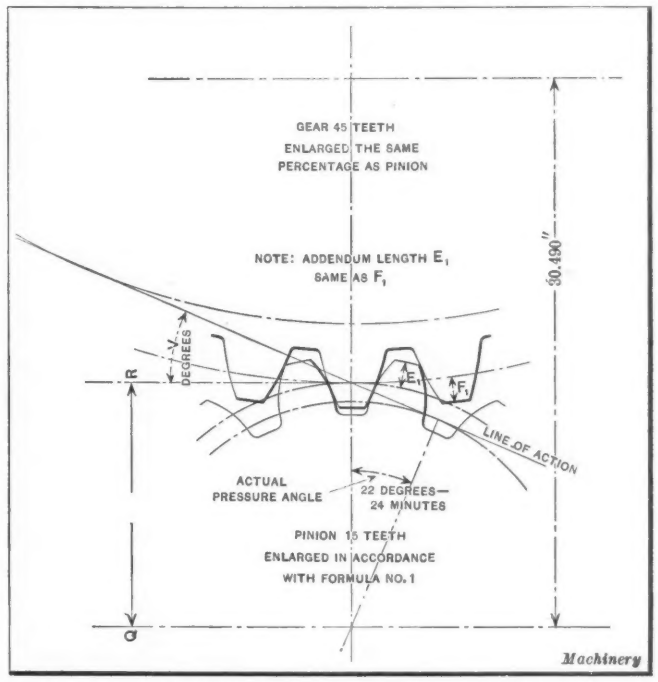


Fig. 8. Gear and Pinion with Same Percentage of Enlargement, and with Center Distance of 30.490 Inches, i. e., increased One-half of Gear and Pinion Enlargement

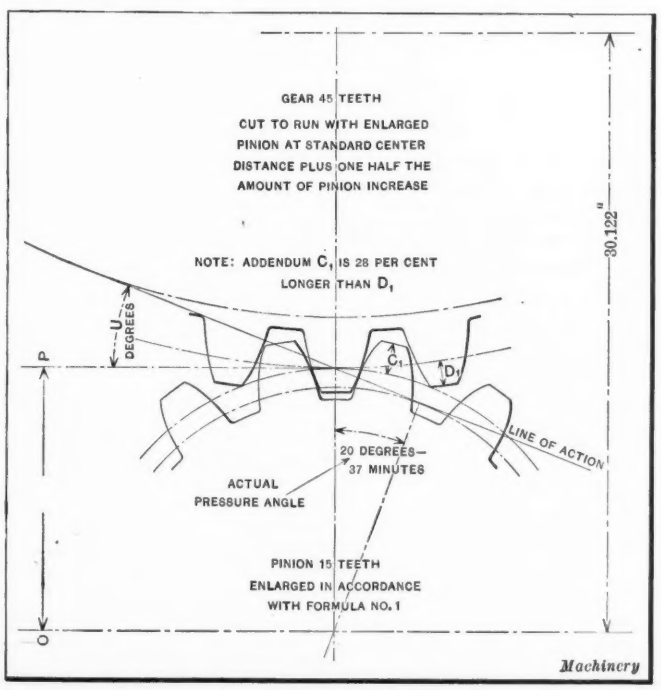


Fig. 7. Enlarged Pinion running with Standard Gear on Center Distance of 30.122 Inches, i. e., increased One-half of Pinion Enlargement

actual pitch line the action is purely rolling, but away from this pitch line slippage occurs. This means wear, which is destructive to the tooth shape so necessary for smooth, quiet gearing. Properly designed helical gears have the virtue of always being in contact in some plane at the pitch line. But a certain amount of tooth length is necessary for serviceable gearing, as although a large part of the load is taken near the pitch line, a certain portion is carried by the remaining tooth surface. It follows then that the sliding action may be better distributed if addenda of gear and pinion, as measured from actual pitch circles, are of the same length. This, of course, can only be accomplished when using an enlarged pinion, by enlarging the gear in the same percentage and running the two members at correspondingly increased center distance, as illustrated in Fig. 8.

* * *

During the last week of December the seventieth meeting of the American Association for the Advancement of Science was held in New York City. The forty national societies affiliated with it met at the same time. In the decade that has passed since the association has met in New York, its membership has grown from 5000 to 11,000.

CUTTING LEAD-SCREWS WITH BOLT DIES

Chasing accurate lead-screws on the engine lathe is one of the most particular and difficult jobs encountered in the machine shop. The work requires experience, a first-class lathe and tools that are correctly ground and set. Chasing a long screw in the ordinary way is a long, tedious job, and it is small wonder that during the period of abnormal demand for lathes, new and more rapid methods have been employed for producing these parts quickly. Most mechanics doubtless would recoil from the proposition of cutting an engine lathe lead-screw with a bolt die, but it can be done and is being done expeditiously and accurately.

One machine tool shop in the Middle West took a large contract for building engine lathes. Not having been builders of lathes before the outbreak of the war, it was not bound by precedent, and did not hesitate to resort to an improved and quicker way of producing lead-screws. A lathe was rigged up with a heavy Landis bolt die on the carriage, preceded by a bushing to guide the stock centrally into the die. The Landis bolt die is provided with tangent cutters, which are ground on the end without changing the shape. The chasers are similar in this respect to the well-known milling cutters which can be ground without changing their form. The tangent chasers also facilitate the cutting and getting rid of the chips. The lathe was provided with a long center in the tailstock that projected through the die and entered the center of the stock, guiding it at the beginning of the cut, as well as supporting it after the cut was well under way. The stock was centered at the headstock end also, and was gripped by a four-jaw chuck which acted as the driver.

The carriage was traversed by the lead-screw, so that the die was relieved of the drag. The dies were ground so that the chips curled and ejected from the front of the die. The chips curled in the same way as though cut with a single-point tool, and no trouble whatever was experienced by clogging. A copious supply of approved emulsion compound was provided to lubricate the die and work and keep them cool.

After considerable experimenting, a production rate of about one foot per minute was secured on lead-screws of six pitch Acme thread, 1¼ inch diameter, about six minutes being required to cut a lead-screw having six feet of thread. After being cut with the bolt die, the screws were taken to another lathe and chased in the ordinary manner with a single-point tool; from 0.012 to about 0.015 inch was left for the two chasing cuts required to finish the screw.

The objection to cutting lead-screws in this manner is that the torsion of the stock introduces an angular error or distortion of the lead of appreciable magnitude. But chasing the screws in the ordinary manner afterward should correct errors of this kind and produce commercial lead-screws, that is, screws of commercial accuracy. Distortion due to the torsion is present in all lead-screws cut with a single-point tool. The amount of angular distortion depends on the depth of the cut, and it is usual practice to correct it by taking very light finishing cuts. The same practice in this case should have the same results and produce approximately correct screws.

Another practice of cutting lead-screws with bolt dies, perhaps not productive of as accurate work as that just described, is taking two cuts—roughing and finishing—with the die. The die is carried along by the lead-screw of the lathe in the same manner as described, so that it is relieved of the drag due to pulling the carriage, and has only to cut the threads. This method has been used successfully for cutting the elevating screws of boring mills and planers, which must be even in lead, although not necessarily accurate in pitch, when measured with a scale; it is essential that two screws or a pair shall raise both ends of a cross-rail the same number of inches and parts of an inch for a given number of turns. If a bolt die used in the manner described serves to cut these screws with commercial accuracy, the practice should not be far astray when applied to cutting lead-screws of engine lathes. Probably a compromise would be to cut the screws with a roughing cut and finishing cut in the die, leaving a few thousandths inch for finishing with a single-point tool in the ordinary manner. Either of these methods is more rapid than milling in the thread milling machine. The thread milling machine produces accurate and satisfactory screws, but many complain that the method is too slow in rush times, when customers clamor insistently for machines.

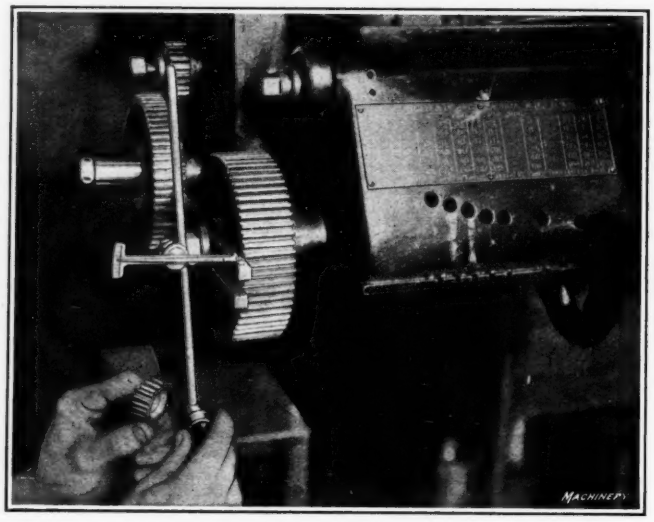
* * *

LATHE FEED-SCREW FOR INDEXING TOOL CARRIAGE

At the plant of the Black & Decker Mfg. Co., Baltimore, Md., the press of business has made it necessary to use some ingenious makeshifts in order to turn out the work. One of the jobs which the company had to do recently was the making of Whitworth threading hobs of the type having parallel grooves instead of a helical groove. The Whitworth shaped grooves are spaced 1/14 inch apart, or fourteen per linear inch. Thus there are fourteen individual grooves per inch of length on the hob instead of one groove of helical form with a lead of 1/14 inch.

The hobs are mounted on an arbor in a 14-inch Flather lathe and a form tool is placed in the tool-holder just the same as though a thread were to be cut. The idler gear connecting the feed-screw and gear train is disconnected. On the leg of the lathe, just below the lead-screw gear, is temporarily clamped an angle iron with its leg approximately parallel to the center line of the lead-screw and spindle. The nut on the lead-screw gear is backed off a sufficient distance to slip two parallel strips between it and the gear.

The gear shift lever is thrown into the position which would be correct for cutting a thread of fourteen turns per inch.



Gaging for indexing Tool Carriage Even Number of Revolutions to Cut Hobs

After cutting the first groove in the hob, the relative location of which is secured by throwing the compound slide around at the proper angle, the tool carriage is moved along exactly 1/14 inch by the operator's revolving the feed-screw gear the proper number of turns—in this case, two. To be assured of getting exactly two turns with no fraction more or less, the height gage fitted with the indicator is employed. With the contact end of the surface indicator resting on the parallel strip, which is clamped tightly to the gear, the gear is brought to a standstill when the indicating needle rests at zero. This process is repeated every time a new groove is cut, and the results obtained are very satisfactory in spite of the fact that this is a makeshift method of doing the job. A little ingenuity on the part of shop men will often easily overcome what would otherwise be a difficult job. V. B.

* * *

The British Minister of Munitions has partly removed the embargo on machine tools, etc. It is now possible to sell, to persons who have a permit to resell them, lathes, milling machines, drilling machines, planers, shapers, screw machines, chucking machines, boring machines, slotting machines, grinding machines, boring and turning mills, power presses, punching and shearing machines, forging machines, cutting-off machines, gear-cutting machines, and centering machines.

INTERNAL SPUR GEARING

DESIGNING AND MACHINING INVOLUTE AND CYCLOIDAL INTERNAL SPUR GEARS

BY REGINALD TRAUTSCHOLD[1]

REDUCED to fundamental principles, all toothed gearing may be likened to plain curved surfaces rolling together, the teeth simply acting as members for the transmission of the power. In other words, all gears may be compared to friction wheels, the pitch surfaces of the toothed gears representing the contact surfaces of the friction wheels. Furthermore, the curvature of a plain curve is measured by the reciprocal of the radius of curvature, and as the curvature of a straight line is zero, comparison of the curvature of two arcs is most conveniently expressed in terms of relative curvature—the straight line being the basis of comparison. These basic laws govern all gearing, but a clear conception of the fundamentals is necessary in a consideration of internal gearing, as it is in this type of gearing that the limitations and inaccuracies of the comparatively universal involute system are most apparent.

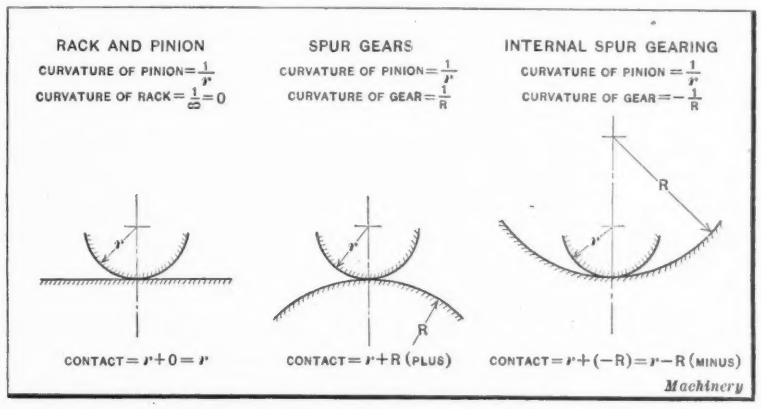

RACK AND PINION
CURVATURE OF PINION = 1/r
CURVATURE OF RACK = 1/∞ = 0
CONTACT = r + 0 = r
SPUR GEARS
CURVATURE OF PINION = 1/r
CURVATURE OF GEAR = 1/R
CONTACT = r + R (PLUS)
INTERNAL SPUR GEARING
CURVATURE OF PINION = 1/r
CURVATURE OF GEAR = −1/R
CONTACT = r + (−R) = r − R (MINUS)
Machinery

Fig. 1. Diagrams of Contact between Curved Gear Profiles

Fig. 1 illustrates diagrammatically the three general types of spur gearing: the rack and pinion, the ordinary spur gears, and internal spur gearing. As the amount of contact between the plain curved profiles is measured by the reciprocal of the relative curvature, the amount of contact for the rack and pinion is measured by the pitch radius of the pinion; the amount of contact for ordinary spur gears, by the sum of the pitch radii of the two gears; and the amount of contact for internal gears, by the pitch radius of the pinion minus the pitch radius of the gear. The contact of internal spur gearing is minus, compared to that of a rack and pinion, and that of ordinary spur gearing is plus. The effect of this, in the practical design of gears, will be apparent by a study of the interference of teeth in a rack and pinion.

From Fig. 2 it is quite evident that interference will occur between the teeth of a rack and a pinion when the point *A*—the intersection of a pinion radial line with the line of pressure or the point of tangency of the line of pressure with the pinion base circle—falls inside of the true rack addendum line. In the case of the rack and pinion, this interference is customarily overcome by shortening the rack teeth by the amount of this interference measured normally to the plane of the rack. The interference naturally increases in amount with the number of teeth in the pinion; and for the true involute form of tooth, with a pressure angle of 14½ degrees, it begins with a pinion of thirty-one teeth.

As the curvature of the ordinary spur gear is equivalent to a certain reduction in the height of the rack tooth, interference is somewhat delayed, and can frequently be overcome by rounding off the corners of the gear teeth. Shortening the gear teeth by the amount of interference would have the same effect, but this is usually a more expensive operation. In the case of internal spur gearing, on the other hand, interference is aggravated in this way, and can only be avoided by a certain modification in the form of the gear tooth.

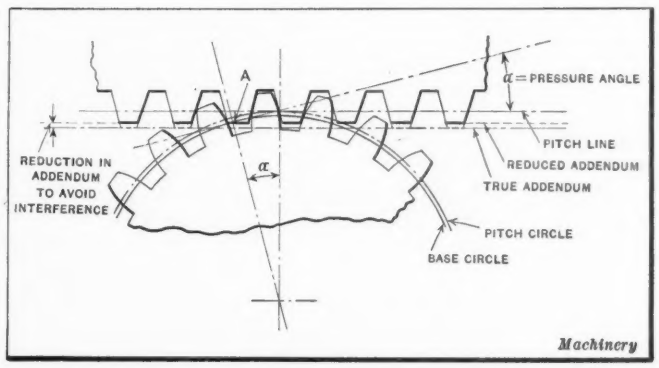


Fig. 2. Interference of Rack and Pinion

Form of Internal Spur Gear Teeth

Fig. 3 is a typical section of an internal spur gear, and shows the alterations in the shape of the regular involute tooth by which interference of teeth is avoided, for any combination of gears in which the pinion has less than fifty-five teeth. Should the pinion have a greater number of teeth, other modifications of the standard involute form of tooth are necessary, and frequently some other system of gearing must be adopted. Such combinations of internal spur gears are comparatively rare, however, and may be considered as special problems, which are advisably solved by laying out the gearing to a suitable scale and modifying both the shape of the pinion and of the gear tooth. A further requisite for the satisfactory operation of involute internal spur gearing is that the difference between the number of teeth in the gear and the pinion is at least fifteen.

For internal spur gear combinations in which the pinion has less than fifty-five teeth, the regular standard involute pinion may be employed, and the modifications required in the shape of the gear teeth may be resolved to definite relationships, which can be expressed in simple and convenient formulas. The dedendum part of the gear-tooth space must be the conjugate of the addendum section of the pinion tooth, plus the clearance. It differs in outline from the tooth space of an ordinary gear in that the profile of the tooth is a concave curve extending past the pitch circle to a point midway between the base and pitch circles of the gear, the location of the interference circle, Fig. 3. The curve bounding this lower section of the gear tooth closely approximates the arc of a circle having a radius equal to one-eighth the pitch diameter of the gear struck about a center located on the base circle. This approximation of a section of an involute curve is very nearly exact for gears with thirty or more teeth; and as the gear almost invariably has more teeth than this, the method is sufficiently accurate for all practical purposes. When the gear has less than thirty teeth or when extreme accuracy is required, a true involute should be developed for that section of the tooth profile lying between the interference circle and the base of the tooth, as this is the true profile of the lower section of the internal spur gear tooth. This refinement, however, is only required when laying out templets, the simpler method being sufficiently accurate for "picturing" internal spur gears.

The modification of the gear tooth to avoid interference is limited to the section within the interference circle. It consists in making the end of the addendum profile conform to the convex arc of a circle, the radius of which is equal to the square root of the sum of the squares of one-eighth the pitch diameters of the respective gear and pinion. This

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is known as the "addendum cutting radius," and the arc is struck about a center on what is known as the "correction circle." The diameter of this correction circle is equal to the pitch diameter of the gear divided by the cosine of the pressure angle.

The location of the interference circle is such that an arc having a radius equal to one-eighth the pitch diameter of the gear, struck about a center on the base circle of the gear, will be tangent at a point on the interference circle, to an arc having a radius equal to the square root of the sum of the squares of one-eighth the pitch diameters of the gear and pinion, struck about a center on the correction circle. The position of the interference circle midway between the base and pitch circles of the gear is naturally dependent, to some extent, upon the relative curvature of the two gears; this accounts for the limitations as to the number of teeth in the pinion.

A pinion with more than fifty-five teeth will so interfere with any practical internal gear that interference will commence at some point on the gear-tooth profile in closer proximity to its pitch circle than midway between the base and pitch circles. This will necessitate an increase in the diameter of the correction circle, and will result in cutting away the ends of the internal gear teeth in order to avoid interference.

Interference of a pinion having but a few teeth with an internal gear having a comparatively large number of teeth would not commence at a point midway between the base and pitch circles of the gear, but the proper correction is cared for by the variation in the length of the addendum cutting radius. This radius is obtained from the sum of the respective proportional pitch diameters of both the gear and pinion, so that when their ratio is comparatively high and the interference correspondingly reduced, the addendum cutting radius is also comparatively large, and but little of the corners of the internal gear teeth are removed. When the ratio between the number of teeth in the gear and pinion is low, provided there is a difference in the number of teeth of at least 15, the addendum cutting radius is correspondingly shortened, and more of the corners of the internal gear teeth removed. This variation in the addendum cutting radius has the same effect as altering the diameter of the interference circle and maintaining constant the length of the addendum cutting radius. The variation in the addendum cutting radius should not be made, however, if there is a difference of less than 15 in the number of teeth in the gear and pinion, as this will ordinarily mean such a low ratio that the addendum cutting radius will be so reduced that the ends of the internal gear will be cut away.

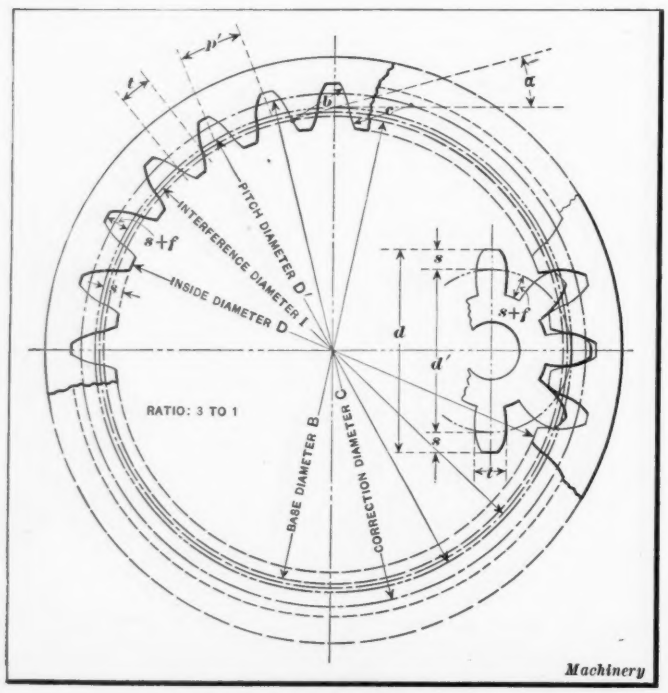


Fig. 3. Lay-out for Internal Spur Gearing

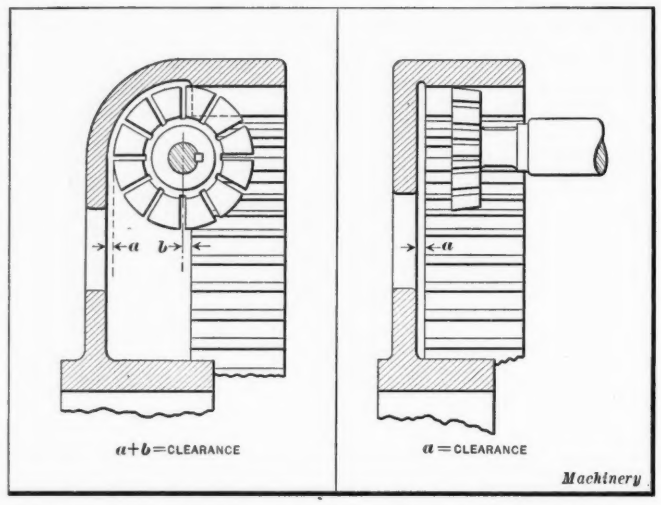


Fig. 4. Internal Spur Gear cut with Rotary Cutter

Fig. 5. Internal Spur Gear cut with Fellows Gear Shaper

Notation for Internal Spur Gearing

	Gear	Pinion
Pressure angle	a	a
Diametral pitch	p	p
Circular pitch	p'	p'
Number of teeth	N	n
Pitch diameter	D'	d'
Outside diameter		d
Inside diameter	D	
Dedendum diameter	D''	
Thickness of tooth on pitch circle	t	t
Addendum	s	s
Dedendum	$s + f$	$s + f$
Clearance	f	f
Working depth of tooth	$2s$	$2s$
Total depth of tooth	$2s + f$	$2s + f$
Base circle diameter	B	
Interference circle diameter	I	
Correction circle diameter	C	
Dedendum cutting radius	b	
Addendum cutting radius	c	

Formulas for Internal Spur Gearing

$$p = \frac{N}{D'}; \text{ or } p = \frac{n}{d'} \quad (1) \qquad p' = \frac{3.1416}{p} \quad (2)$$

$$D' = \frac{N}{p}; \text{ or } D' = 0.3183\,Np' \quad (3)$$

$$d' = \frac{n}{p}; \text{ or } d' = 0.3183\,np' \quad (3a)$$

$$d = \frac{n+2}{p}; \text{ or } d = d' + 0.6366\,p' \quad (4)$$

$$D = \frac{N-2}{p}; \text{ or } D = D' - 0.6366\,p' \quad (5)$$

$$D'' = \frac{N+2.314}{p}; \text{ or } D'' = (0.7366 + 0.3183N)\,p' \quad (6)$$

$$t = \frac{1.5708}{p}; \text{ or } t = \frac{p'}{2} \quad (7) \qquad s = \frac{1}{p}; \text{ or } s = 0.3183\,p' \quad (8)$$

$$s + f = \frac{1.157}{p}; \text{ or } s + f = 0.3683\,p' \quad (9)$$

$$f = \frac{0.157}{p}; \text{ or } f = 0.05\,p' \quad (10)$$

$$B = D' \cos a \quad (11) \qquad I = 0.5\,(B + D') \quad (12)$$

$$C = \frac{D'}{\cos a} \quad (13) \qquad b = \frac{D'}{8} \quad (14)$$

$$c = \sqrt{\left(\frac{D'}{8}\right)^2 + \left(\frac{d'}{8}\right)^2} \quad (15)$$

Discussion of Formulas

The formulas presented for the pinion member of an internal spur gear combination are similar, of course, to the well-known formulas for the ordinary type of spur gear. The main difference, other than the special formulas for the curves of the tooth profile, lies in the fact that the teeth are in an

opposite position as compared to those of the ordinary variety of spur gear. That is, the dedendum diameter of the internal spur gear is as much greater than its pitch diameter as the addendum, or outer, diameter of an ordinary spur gear of the same number of teeth and similar pitch is greater than its pitch diameter, plus twice the clearance.

The importance of the inner diameter of an internal spur gear is, therefore, as great as that of the outer diameter of the more common type, so that twice the addendum is subtracted from the pitch diameter of an internal spur gear to obtain its inner diameter, just as twice the addendum is added to the pitch diameter of an ordinary spur gear to obtain its outer diameter. The thickness of the tooth on the pitch circle, addendum, dedendum, and clearance for internal spur gears is obtained in a manner similar to that employed for spur gears of the customary type.

Example in the Design of Internal Spur Gearing

Example:—Required, an internal spur gear combination; 8 diametral pitch, 64 teeth in gear, 20 teeth in pinion; 14½-degree pressure angle.

$$p' = \frac{3.1416}{8} = 0.3927 \text{ inch} \quad (2) \qquad D' = \frac{64}{8} = 8 \text{ inches} \quad (3)$$

$$d' = \frac{20}{8} = 2.5 \text{ inches} \quad (3a) \qquad d = \frac{20 + 2}{8} = 2.75 \text{ inches} \quad (4)$$

$$D = \frac{64 - 2}{8} = 7.75 \text{ inches} \quad (5)$$

$$D'' = \frac{64 + 2.314}{8} = 8.28925 \text{ inches} \quad (6)$$

$$t = \frac{1.5708}{8} = 0.19635 \text{ inch} \quad (7) \qquad s = \frac{1}{8} = 0.125 \text{ inch} \quad (8)$$

$$s + f = \frac{1.157}{8} = 0.144625 \text{ inch} \quad (9)$$

$$f = \frac{0.157}{8} = 0.019625 \text{ inch} \quad (10)$$

$$B = 8 \times 0.96815 = 7.745 \text{ inches} \quad (11)$$

$$I = 0.5\ (7.745 + 8) = 7.8725 \text{ inches} \quad (12)$$

$$C = \frac{8}{0.96815} = 8.261 \text{ inches} \quad (13)$$

$$b = \frac{8}{8} = 1.000 \text{ inch} \quad (14)$$

$$c = \sqrt{\left(\frac{8}{8}\right)^2 + \left(\frac{2.5}{8}\right)^2} = 1.048 \text{ inch} \quad (15)$$

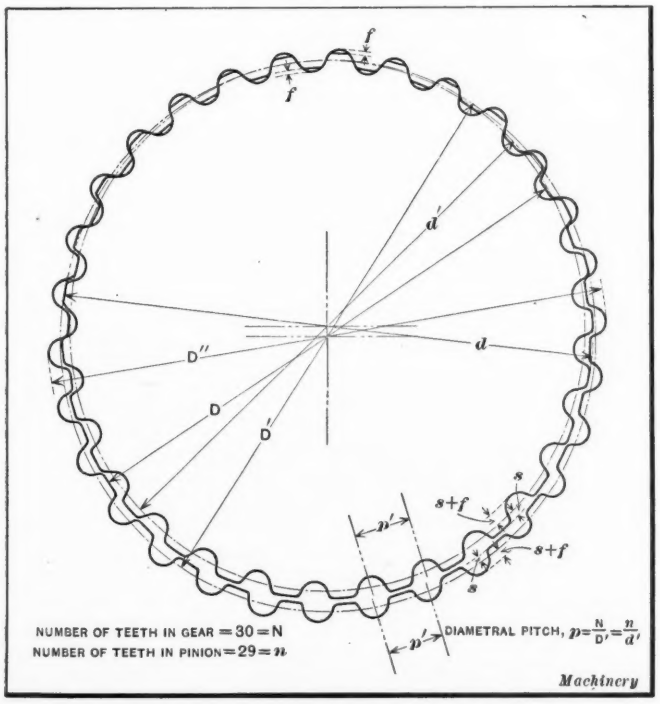


Fig. 6. Lay-out for Cycloidal Internal Spur Gearing

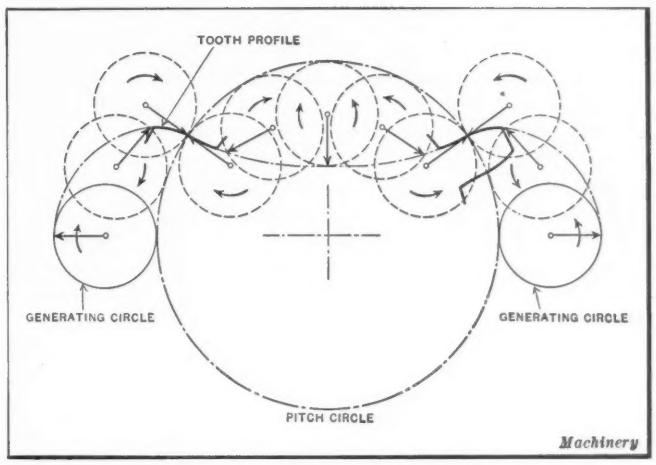


Fig. 7. Generating Cycloidal Tooth

Machining Internal Spur Gears

The teeth of internal spur gears are awkwardly located for machining operations, unless the gear is of the ring type, or composed of segments of a ring, with lugs protruding from the outer circumference of the gear ring by which the gear can be attached to some supporting structure. The gear teeth may be cut with a rotary cutter, milled, or cut with a machine of the Fellows gear-shaper type, depending on the general design of the gear.

Fig. 4 shows the variety of gear for which the rotary cutter may be employed and indicates the clearances that must be allowed. A special cutter is usually required, but when accuracy is not absolutely essential, a No. 1 standard rotary cutter may be employed for gears of 4 diametral pitch and finer, provided the gear has sixty or more teeth. The greater the number of teeth and the finer the pitch, the more satisfactory is the standard cutter for internal teeth. The operations involved in milling internal spur gear teeth are similar to those for cutting ordinary spur gears, but the rate of production is not usually as high, owing to the greater difficulty of interior work and the necessity of exercising more care than when working on an exterior surface.

Machining internal spur gears on a shaper permits a much more compact design of gear, as is shown in Fig. 5. Clearance for the tool is required, but this can be kept as low as 3/16 inch with a Fellows gear shaper. This is naturally a decided advantage, but it is gained only through the sacrifice of speed in production, the rotary cutter being by far the more efficient tool.

Internal Spur Gears of Low Ratio

The involute system of internal gearing, requiring a difference of 15 in the number of teeth in the gear and pinion, does not lend itself to many installations where the difference in the number of teeth must necessarily be slight. In such cases, the cycloidal system of gearing is usually adopted. Its freedom from the drawbacks of interference permits the successful solution of many problems where the difference in the number of teeth in the gear and the pinion is so slight as to prohibit the use of gears with teeth resembling in any way the involute form. Fig. 6 illustrates an installation in which the gear has thirty teeth and the pinion twenty-nine.

The profile of the cycloidal tooth is traced by a fixed point on the circumference of a "generating circle" which is rolled above and below the pitch circle of the gear. The rotation of the generating circle is always in the same direction when tracing the profile of one side of the tooth and in the other for the opposite side, as is shown in Fig. 7. As the diameter of the generating circle is the same for the teeth of both pinion and gear, the interference that is so noticeable in internal gears of the involute variety can be entirely obviated.

In the cycloidal system of gearing, a generating circle of half the size of the pitch circle develops teeth with radial flanks; one of less than half the pitch circle, teeth which spread out toward the root and which are, therefore, of greater strength; while teeth developed by a generating circle of a diameter less than one-half the pitch diameter curve in toward

one another and are weaker and more difficult to cut. The standard size of generating circle has a diameter equal to the radius of the pitch circle of a gear having twelve teeth of the same pitch as the gear to be developed, providing, of course, that the gear for which the generating circle is adopted has twelve or more teeth. This standard is not fixed, however, as many gear makers use the pitch radius of a gear with fifteen teeth as the base. The twelve-tooth standard will be used, however, in the derivation of the following formulas for obtaining the diameter of the generating circle.

Generating Circle Formulas

N = number of teeth in cycloidal base gear = 12;
p' = circular pitch;
p = diametral pitch;
G = diameter of generating circle.

$$G = 0.5\ (12 \times p' \times 0.3183) = 1.9098\,p' \qquad (A)$$

$$G = 0.5 \times \frac{12}{p} = \frac{6}{p} \qquad (B)$$

The formulas employed for the solution of internal spur gearing of the involute type also govern the calculations for cycloidal internal gears, but no modifications for avoiding interference need be made. Formulas 11 to 15, inclusive, therefore, do not have to be employed. The pitch diameter of the pinion should be equal to or greater than twice the diameter of the generating circle to insure a tooth of adequate strength. If care is taken to see that the minimum pitch diameter of the pinion is at least equalled, which will result if the formulas for the generating circle are used, the calculations involved in the design of cycloidal type internal spur gearing are no more laborious than those necessary for a problem in the design of an ordinary pair of external spur gears.

Example:—Required, an internal spur gear combination with cycloidal teeth; 8 diametral pitch, 32 teeth in gear and 24 teeth in pinion.

$$G = \frac{6}{8} = 0.75 \text{ inch} \quad (B) \qquad p' = \frac{3.1416}{8} = 0.3927 \text{ inch} \quad (2)$$

$$D' = \frac{32}{8} = 4 \text{ inches} \quad (3) \qquad d' = \frac{24}{8} = 3 \text{ inches} \quad (3a)$$

$$d = \frac{24 + 2}{8} = 3.25 \text{ inches} \quad (4) \qquad D = \frac{32 - 2}{8} = 3.75 \text{ inches} \quad (5)$$

$$D'' = \frac{32 + 2.314}{8} = 4.28925 \text{ inches} \quad (6)$$

$$t = \frac{1.5708}{8} = 0.19635 \text{ inch} \quad (7) \qquad s = \frac{1}{8} = 0.125 \text{ inch} \quad (8)$$

$$s + f = \frac{1.157}{8} = 0.144625 \text{ inch} \quad (9)$$

$$f = \frac{0.157}{8} = 0.019625 \text{ inch} \quad (10)$$

* * *

BULLARD INSURANCE PLAN

The Bullard Machine Tool Co., Bridgeport, Conn., has issued a statement to its employes of an insurance plan based on length of service, which became effective November 14, from which the following was taken:

An insurance certificate for $500 will be given to an employe upon the completion of six months of continuous employment.

After one year of continuous employment has been completed, the value of the certificate will be increased to $600.

For each year of continuous employment thereafter, $100 shall be added to the value of the certificate until a maximum of $1500 has been reached.

This plan shall be retroactive so that all individuals who have been continuously in the employment of the company for ten years or more will at once receive a certificate for the maximum amount of insurance under this plan.

The new insurance plan, which will affect about one thousand employes of the company, provides for insurance in case of total disability as well as death; it provides for payment in installments over a term of years, in order to safeguard the recipients from unwise investments and to assure them of the maximum benefit to be derived.

THE TELEGRAPHONE

The telegraphone is an apparatus invented by Valdemir Poulsen, the Danish inventor, which makes use of the principle of electromagnetism for recording and reproducing sound waves. It may be defined as an apparatus for reproducing at a distance the sound which produced a graphonic record; also as an apparatus for producing a graphonic record at a distance by means of a telephonic circuit. A wire is used for recording the sound waves, the wire being magnetized so that the sound waves are impressed in the form of energized poles of varying intensity. This principle was developed by the inventor several years ago, but it is only lately that it has been possible to produce an instrument which would give entire satisfaction.

There were two requirements that had to be satisfactorily met before the device could be a success. One was the manufacture of a fine wire sufficiently coarse-grained and porous to be easily magnetized and in which the magnetism would remain permanently, and at the same time have sufficient strength to withstand a tensile stress of eighteen to twenty pounds. The other was to produce a winding device which could be instantly reversed, started or stopped without producing slack in the wire. The wire found most satisfactory was 0.010 inch diameter piano wire having a carbon content of 1.20 to 1.30 per cent. It is wound on spools, in lengths of about six miles, which permits the instrument to run for thirty minutes without changing reels.

Principle of Telegraphone

In principle, the telegraphone consists of a mechanism comprising two vertical shafts carrying spools on which the steel wire 0.010 inch in diameter is wound or unwound. One of the shafts is rotated at the desired speed by means of a fractional horsepower motor. The wire, in passing from one spool to the other, is guided by a German silver bushing and passes in close proximity to an electromagnet which converts the sound waves transmitted to the instrument into the form of magnetic poles in the wire of varying intensity, depending on the pitch of the sound. The "sweeping" magnet is carried on the other side, so that by reversing the direction of rota-

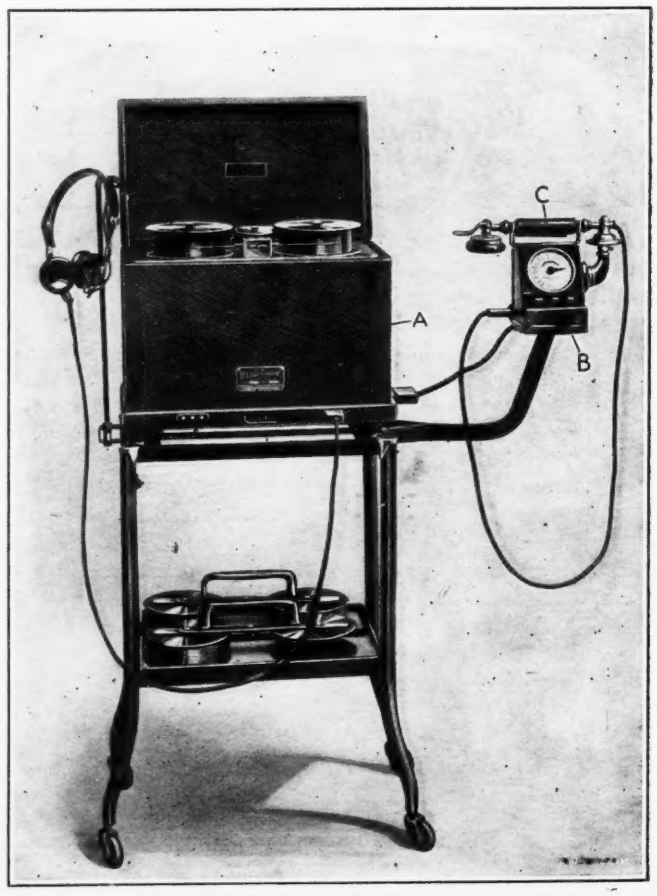


Fig. 1. Dictating Machine made by the American Telegraphone Co., which employs Principle of Electromagnetism for Sound Reproduction

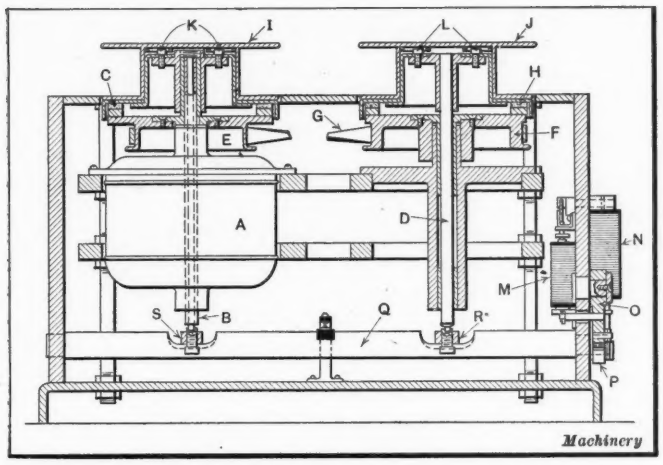


Fig. 2. Diagram showing how Wire Reels on Machine shown in Fig. 1 are reversed without producing Slackness in Wire

tion of the wire, the intensity or height of the magnetic poles can be equalized. Complete demagnetization does not take place, but instead of putting up or raising a series of electric poles in the wire of varying intensity, all these poles are reduced to the same intensity, and hence no reproduction is given off.

As shown in the illustration, Fig. 1, the instrument *A* is operated by an extension set *B* which carries three buttons; one is for starting or stopping the machine, one for rotating it backward, and the other for rotating it forward. This extension set also carries an electric buzzer which rings about one-half minute before the spool of wire is exhausted. The extension set can be located, if necessary, a mile away from the telegraphone proper and used like a telephone, having both a transmitter and receiver *C*. The other connection between the extension set and the telegraphone proper is the switchboard, not shown, which is almost identical with the ordinary telephone switchboard. The switchboard can be plugged with the extension set and the telegraphone, and records can be made on the machine or taken off, as desired.

Applications of Telegraphone

As will be understood from the preceding, the telegraphone can be used for recording a telephone conversation. In addition, it can be used as a dictating machine, and it is superior to the present dictating machines in several ways: (1) There are no records to shave or break. (2) The constant rasping noise so annoying in the wax record machine is entirely removed. (3) The strain on the transcriber is no greater than when listening to the telephone. (4) It can be used for carrying on telephone conversations between departments. (5) The machine is remote from the dictator, permitting him to concentrate, as there is no machine to attend to. (6) It requires thirty instead of ten or twelve minutes for one reel to unwind. (7) The record is permanent and is not affected by temperature changes. (8) The spoken words are reproduced clear and distinct. (9) Corrections can be easily made, by simply reversing the instrument and dictating over the portion to be corrected. (10) The system is entirely electrical.

In the musical field, the development is not yet complete, but it is anticipated that the next few years will see a great advance in the application of this instrument to the reproduction of operas and music of all kinds. In fact, it is reported that the Automatic Electric Co. of Chicago, Ill., maker of the automatic telephones, is at present offering the use of this instrument to its subscribers for a small additional charge. The telegraphone is installed in the distributing or central station, and subscribers can have music for one hour every evening over the telephone. An amplifier can be located in a flower vase or any place in the room and connected with the telephone. In this way records can be reproduced without the subscriber's having to do anything but remove his receiver from the hook.

Another application which is being developed is the use of the telegraphone in connection with the motion picture machine. The talking picture has never been made a success because of the difficulty of obtaining perfect synchronism between the pictures thrown on the screen and the recording of the voice. With the telegraphone, perfect synchronism is possible. This is accomplished by depositing a strip of pulverized iron filings directly on the film itself. The sound waves are thus carried directly on the same film as the pictures. In reproducing, an amplifier can be located behind the curtain and connected telephonically with the motion picture machine.

Method of Operating Telegraphone

The telegraphone is operated, as previously mentioned, by an extension set which has three buttons: one for starting and stopping, one for making the machine run forward, and the other for making it run in the opposite direction. These buttons are wired to magnets which serve to operate the driving mechanism. One of the most interesting points in connection with this mechanism and the one that was most difficult to control is the means provided for automatically stopping and reversing the spools on which the wire is carried, without breaking the wire or allowing it to slacken. Reference to Fig. 2 will show that a motor *A* inside the box drives shaft *B* through a friction clutch *C*. When it is desired to wind the wire in the opposite direction, the other shaft *D* is connected by a cross belt *G* operating on pulleys *E* and *F*. Both spools *I* and *J* are driven in a similar manner by means of screws *K* and *L*, respectively, fitting in projecting lugs on the lower inner surface of the spools.

In order to prevent slackness in the wire, it was necessary to provide a means for rotating alternately first one shaft and then the other, the shaft carrying the spool on which the wire was being wound being the driven shaft. In order to accomplish this, it was necessary to lift the member that was not driven from the clutch, and thus depend on the driven shaft to pull or unwind the wire from the spool held on the opposite shaft. This lifting of the different spools is controlled both magnetically and mechanically, and is effected through magnets *M* and *N*, segment gear *O*, and pinion *P*, respectively. Pinion *P* is fastened to shaft *Q*, which has flattened surfaces coming in contact with levers *R* and *S* that carry supports for the spindles carrying the spools. Movement of this shaft lifts one spool or the other, depending on the direction in which the wire is being wound.

In operation, the pressing down of the button shown to the left on the extension set in Fig. 1 energizes a relay magnet from the battery. This magnet attracts an armature which closes the contact and allows alternating currents to flow to the operating magnet *N*. Magnet *N* is instantaneously energized and attracts its armature, thereby rocking shaft *Q* in a counter-clockwise direction. This action lifts lever *R* and thereby spindle *D*, thus removing the driving drum from the friction clutch *H*, and releasing reel *J*. Mechanical means are provided for holding shaft *Q* in the position in which it is operated by the mechanism, so that further energizing of the magnet is unnecessary. At the same time that lever *R* is lifted, motor *A* is connected with the source of power and drives shaft *B*, pulley *E* and reel *I*. When it is necessary to stop the machine, the operator pushes the central button, Fig. 1, which closes the circuit and stops the operation of the motor.

To operate the apparatus in the reverse direction, the button on the right of the control *B*, Fig. 1, is depressed. This operates a relay and magnet and closes the contact whereby magnet *M* is momentarily energized and rocks shaft *Q* in a clockwise direction. This actuates lever *S* and consequently lifts shaft *B*, removing reel *I* from driving pins *K*. Thus this reel is allowed to run loosely. The reel or spool *J*, however, is still in contact with the friction element and positively driven by pulleys *E* and *F* through cross belt *G*. Thus the wire is unwound from reel *I* and rewound upon reel *J*. The mechanism can be again stopped when the end of the wire is reached by operating the middle button of the three on the control set. D. T. H.

* * *

An imitation gold alloy consists of 81 per cent copper, 9 per cent nickel, and 10 per cent zinc.

JAPANNING CUSHION SPRINGS BY THE AIR-DRYING PROCESS[1]

EFFICIENT SYSTEM OF HANDLING SPRINGS IN AN AUTOMOBILE PLANT

BY E. F. LAKE[2]

COIL springs that go into the seats and backs of automobiles are japanned to prevent rusting and to give them a better appearance than they would otherwise have. As such springs are covered with upholstery, their appearance is not of great importance, but it is essential that the steel be prevented from rusting, for rust does not have to eat very far into wire of such diameters in order to seriously reduce its strength and resiliency. Cushion springs for automobiles are made and used in large quantities, and the cost of production has become an important factor. Those who install the most automatic machinery are the ones that do away with the greatest amount of hand labor and reduce manufacturing costs to a minimum.

Some novel and efficient automatic appliances are part of the equipment of the Detroit Wire Spring Co., Detroit, Mich., whose practice in making automobile cushion springs was described in the November number of MACHINERY. On the third floor of the factory are made the springs for the back of the seat in Ford cars, and an air-drying japanning process is installed there, which will be described in the following.

Coil spring makers have always considered that it was necessary to heat springs to about 450 degrees F. to remove any internal strains that might have been set up in the wire when it was twisted into coils and then knotted at each end. The wire makers harden the wire used in such springs and give it the proper temper for cushion or bed springs, before it is shipped to the spring maker; but the spring makers say the coil springs would break quickly if they were not tempered after they had been coiled and knotted, and when baking japan on these coil springs, the temperature used is nearly always about 450 degrees F. In that case the steel in the spring is heated enough to overcome internal strains, and the springs are tempered while the japan is being baked. With an air-drying japanning process the springs do not get this heat-treatment, however, and thus it requires a separate operation for tempering the steel.

When the air-drying process was started in this shop arrangements were made for tempering the coil springs in bundles, before they were assembled for the seat or back cushion; and Fig. 1 shows the oven or furnace that was installed for tempering these springs. A trolley system like that on the lower floor, described in the article in the November number, is used to deliver the springs to this tempering oven, hold them while in the oven, and afterward deliver them to the assembling benches. The single track, over which the springs travel to the oven, branches into three parts while going through the oven, and these converge into one track again just outside the opposite end. The bundles of coil springs can be seen in the wire baskets that are just rolling over the trolley system and into the oven. The carrier is merely a 2-inch gas pipe that hangs by two ⅝-inch bolts from a set of roller-bearing wheels which are inside the trolley tracks.

Each track in the oven holds six of these baskets, so that a full charge means eighteen baskets loaded with approximately twenty-seven gross of coiled springs. With this method a full charge of springs can be put in the oven in about one minute, after which the doors are closed and the springs are held in the oven until they absorb all the heat that is necessary for correct tempering. This should not take over ten minutes, if the furnace or oven is maintained at the correct temperature. Then the doors at the opposite end of the oven are opened, and the springs are made to travel on to benches, where they are assembled into seat and back springs.

Fuel oil is used for heating this oven, and the burners are shown at *A*. These shoot the flames into the lower part of the oven, which is brick lined and forms the combustion chamber. The heat radiates from here into the upper compartment, where the springs are located. The walls of this upper compartment are built like an ordinary japanning oven, from two sheets of metal, between which is about 2 inches of corrugated asbestos board. Pipes *B* vent the tempering chamber of the oven, while pipe *C* vents the lower combustion chamber. These carry the spent gases or fumes to the outer atmosphere, through a single opening. The wire reels shown in front of this oven are connected with part of the bank of wire straightening machines shown in Fig. 2. From these reels the wire is fed into the machines, which roll it out into straight wire, cut off pieces of the desired length, and drop them into racks *D*. The straightened wire is taken from racks *D* to the benches at *E*, where it is bent into shapes such as shown at *G*. These wire frames form the top or bottom of assembled seat and back springs and give them their proper size and shape.

The coils of wire are brought from the freight cars to these reels by elevators, roller conveyors and an overhead trolley system. A covered platform extends along the outside of the building and the freight cars are unloaded onto this platform. The elevator shown in Fig. 3 is used to carry the wire coils to the upper floor of the building. Roller conveyor *F* can be extended into the freight cars and pulled out again when the cars are unloaded; and the coils are sent over these rollers from the freight car to the platform *H*. The elevating part

[1] See also "Manufacture of Automobile Cushion Springs," in the November, 1916, number of MACHINERY.

[2] Address: 352 Belvidere Ave., Detroit, Mich.

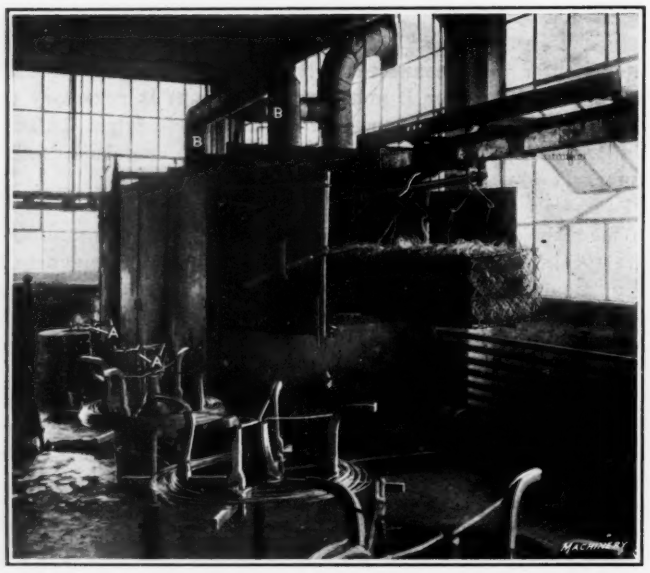


Fig. 1. Oven for tempering Springs in Bundles before they are assembled

Fig. 2. Straighteners for preparing Wire for Cushion Spring Frames

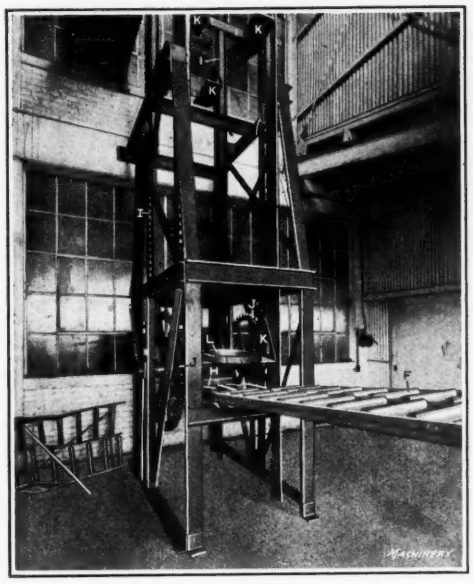


Fig. 3. Elevator used to carry Coils of Wire to Upper Floors

of the mechanism consists of chains *I* which travel over sprocket wheels *J* and carry the arms *K*. As arms *K* travel upward they straddle platform *H* and pick up the wire coils or rolls of band iron shown at *L*. Chains *I* travel over another pair of sprocket wheels at the top of the elevator. The load is carried over the top and down the opposite side. On the way downward, arms *K* straddle extensions of roller conveyors that are located on each upper floor of the building. To drop the coils of wire or rolls of band iron at the floor desired, it is only necessary to swing the conveyor extension on that floor into place. When dropped on this extension they enter the building as shown in Fig. 5, through the window at *M*. The coils then travel over these rollers to different parts of the conveyor and are dropped to the floor close to the machines that use them. At *O* there is a joint in the conveyor, and here the rollers can be lifted enough to allow the wire or band iron to drop to the floor through chute *P* and over rollers *R*. Similar breaks can be made wherever it is desired to bring the material to the floor.

In Fig. 4 is shown an ingenious device used for assembling the coil springs that pass through the tempering oven shown in Fig. 1, and the wire foundation frames shown at *G* in Fig. 2. The men work so close together they had to be moved from this bench while the picture was being taken. There are ten of these benches placed side by side across the shop. It is quite a sight to see the speed at which the men work while standing elbow to elbow, and also the number of springs that they can assemble in a short period of time.

On these benches are assembled all the back springs for the seats in Ford motor cars. At the far end of each bench the men start with the wire foundation frames. One of these is placed over the wooden pins in a rack like that shown at *N*. This rack then starts a continuous movement along the bench on wheels *S* which line both sides of the opening in the bench. As it travels from one man to the other, each one does his part, and when it arrives at the near end, the back spring is completely assembled as shown at *Q*. When thus completed, the spring is hung on a carrier which travels over the trolley system with tracks over the gangway at this end of the benches. As fast as the springs are taken from the racks at *N*, the racks drop through an opening in the bench and roll down an inclined set of wheels to the far end of the bench, where they are again raised to the top to start carrying work through another assembling operation. The finished springs are carried by the conveyor to the japanning department.

Efforts are continually being made to reduce the cost of the japanning process. The japans are continually being experimented with to reduce the amount of heat and time that is required to produce a hard, smooth and lustrous coating. The ideal condition for this work would be to dip the piece in liquid japan that would dry the instant it was removed but we are a long way from attaining this ideal. In most cases the japan is baked in ovens, after it has been coated on the work by dipping, spraying or brushing. The same effect might be obtained if the japan coat were allowed to stand in the air until it dried, but a greater hardness and wearing quality is obtained if the baking time is not too long or too short and the correct temperature has been maintained. The baking process also makes the work ready to use in from twenty to sixty minutes, and thus is cheaper than a slow air-drying process, because of the storage space and time that is saved.

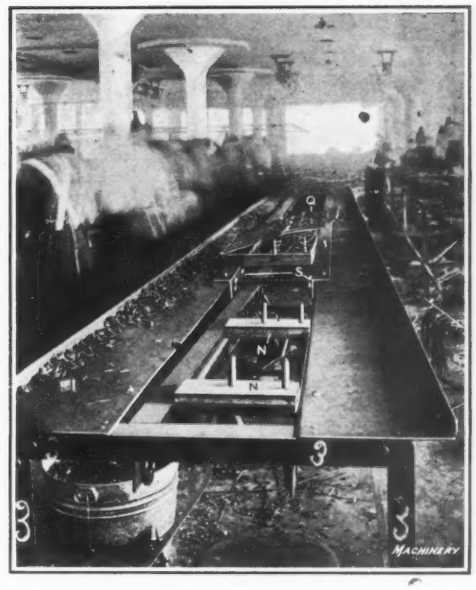


Fig. 4. Bench on which Cushion Springs for Seat Backs are assembled

Japans have been greatly improved during the past few years, and quick air-drying japans are now being produced that give satisfactory results for some classes of work. The use of such air-drying japans is rapidly increasing with the makers of cushion springs, and the most modern application of this process is herewith described and illustrated. It does away with the use of heat insulated ovens for baking the japan coat and the cost of the fuel and apparatus that is required for heating these ovens. When a carrier is fully loaded with springs at the benches shown in Fig. 4, it travels over the trolley track, shown at *T* in Fig. 6, which curves over the japan dip tank. This tank is located at the end of the gangway which passes the assembling benches. Here the springs are coated with japan by lowering them with an air hoist until they are completely submerged in the liquid japan. At *U* will be plainly seen how a loose piece of track and the load of springs is lowered with the air hoist. When coated, the springs are again raised to the track level and sent over the drain board as shown at *W*, where they stop long enough to allow the excess japan to drip from them and flow back into the dip tank.

In Fig. 7 will be seen how the springs then travel along the trolley system to the craters. The japan dipping tank is located at the far end of the track shown at *V*, and while the springs are moving over this 250 feet of track, the air has had time to dry the japan and make it hard enough to handle when it reaches the craters. Track *X* has plenty of work to do, even though it did not carry any springs at the time this picture was taken. At the far end it curves over the dip tank and conveys the work from other parts of the shop to the japanning apparatus. It is usually loaded with work. The two craters shown in the foreground crate most of the

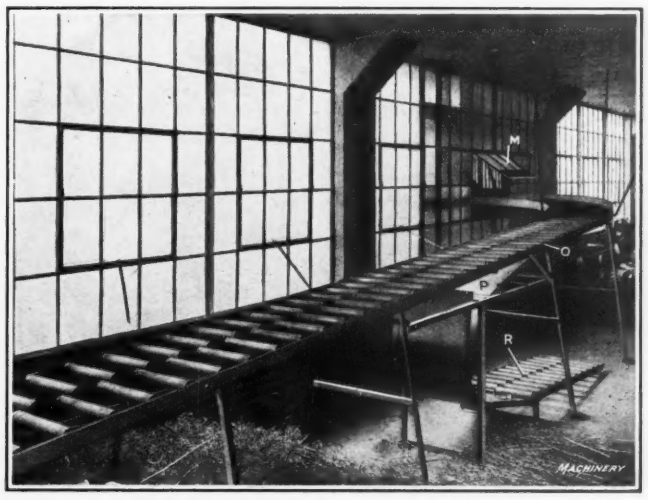


Fig. 5. Conveyor for carrying Coils into Shop and delivering them to Machines

springs that have been through the air-drying process. They take the springs off the trolley system at this point and stack them to the top of and between the four posts of the framework shown. Then they place the top of a crate over the springs and throw the wooden platform *Y* on top of it. After that, they sit on the platform handles as shown and compress the springs into a small bundle before nailing on the side strips which hold the crate together. Back springs do not have the coils as close together as seat springs, nor do they have as many rows. Thus when the loose springs are thrown in between these posts, they occupy approximately four times as much space as they do when in the crate, and it requires the weight of two men to compress them that much.

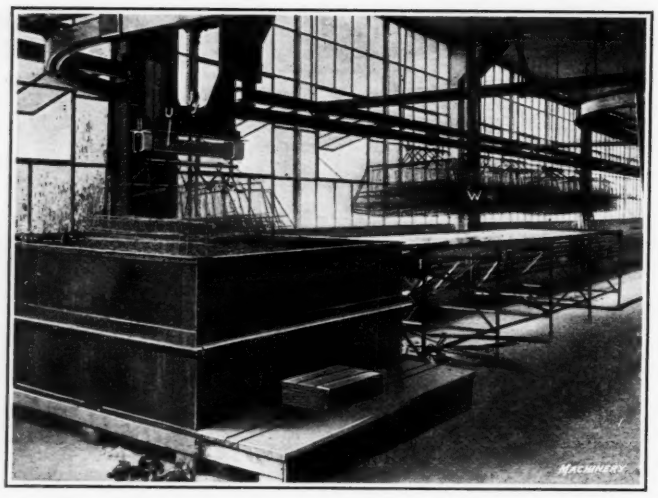


Fig. 6. Arrangement of Dip Tank in which Springs are japanned

In Fig. 8 will be seen a conveyor which serves the entire third floor through the center of the building, and an elevator which lowers the work to the shipping room on the ground floor. The trolley system for air-drying the japan runs along the wall to the right of this view, and the craters are located some thirty feet to the right of the elevator. The pile of crates they have stacked up ready for the elevator is shown at *A*. This conveyor is operated by an electric motor and other apparatus located at *B*. It brings the work from both ends of the shop and delivers it to platform *C*, which is located directly in front of the elevator. All the springs that are made on this floor do not go through the air-drying japanning process, and this conveyor brings to the elevator the springs which are not japanned. Arms, like the two shown at *D*, project out from the elevator apparatus at certain equally spaced positions; and on these either the crates or loose springs are loaded and lowered to the shipping room. From here the loose springs can be loaded on a trolley system and sent through the japan baking process described in the November number.

While the men were removed from the different views in order to make better pictures, it was only at the assembling bench shown in Fig. 4 that many men had to be removed. This is due to the fact that so much automatic and semi-automatic machinery has been installed that it does not require very much labor to turn out the large production of springs that the Detroit Wire Spring Co. manufactures in its new shop. The cushion springs that go into the Ford cars alone would make a large production for any shop; but, in addition, this company manufactures the cushion springs that are used in the Packard cars, and also has contracts that call for a large production of springs for other automobile manufacturers. With its present equipment the company is enabled to manufacture such springs at a very low cost, but the management is continually looking for and inventing other appliances that will still further reduce the cost of production.

* * *

STEEL WELDING

The constantly increasing price of high-speed steel now makes it almost prohibitive for the average shop to use cutting tools composed wholly of such material. Furthermore, with high-speed steel at present prices, it is very costly for a shop to have to scrap worn-out tools. Such problems, however, can now be solved and noticeable economies effected by welding high-speed steel tips to ordinary machine steel shanks. Thus old worn-out high-speed steel tools can be cut to proper size and utilized for tips at a great saving.

The high-speed steel tip is first "tacked" to the machine steel shank and the whole preheated. After fluxing with borax, welding is started. After welding, the tool is immediately laid in mica dust to cool gradually. It is then rough-ground and tempered, after which the finish-grinding is accomplished, when the tool is ready for use. Reinforcing metal is built out and around the tip, which serves both to give larger radiating surface and to afford a larger conducting path back to the butt of the tool, thus keeping down the temperature at the cutting edge. The machine steel shank may be of any length desired, and of cold-rolled, hot-rolled, or carbon steel, while the high-speed steel tip should be short.

The Westinghouse Electric & Mfg. Co. of East Pittsburg, Pa., which is at the present time using cutting tools with high-speed steel tips and machine steel shanks for many of its planers and lathes, has found the electric arc process of welding very satisfactory and much cheaper than any other process. This conclusion has been reached after tests employing oxy-acetylene and forging methods. The ordinary electric arc welding equipment made by the company is used, and is the same as that required for the welding or repair of castings. For best results, the current for this work should be approximately 100 amperes, and the voltage of the welding circuit 60 to 70 volts. A 5/32-inch Norway iron electrode should be used. The work should not be hurried, but a good operator should be able to make between twenty-five and thirty welds for tools of 1½-inch cross-section in a day of nine and one-half hours.

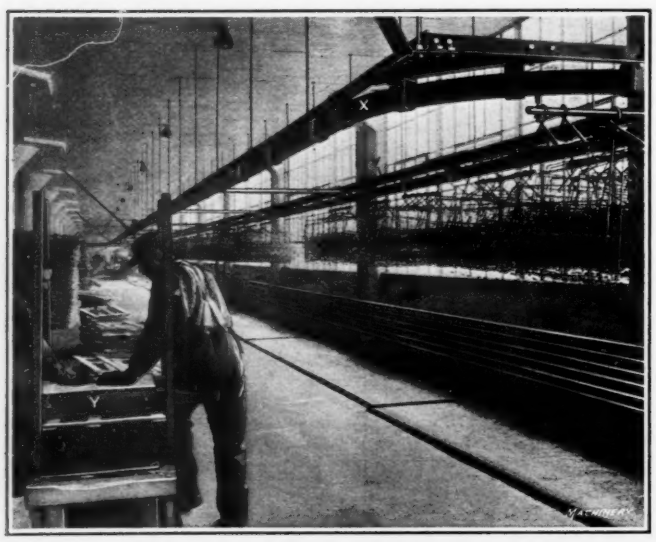


Fig. 7. Conveyor leading to Packing Room, and Method of crating

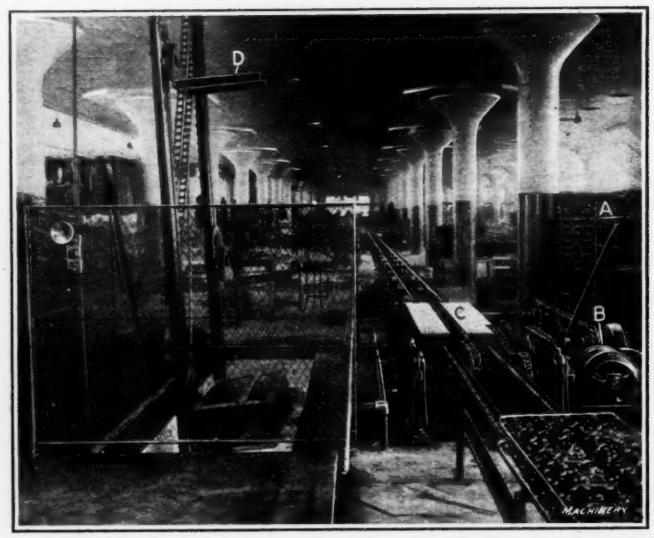


Fig. 8. Conveyor System for Third Floor, and Elevator to Shipping Room

A SIMPLE AND ACCURATE BALANCE FOR THE SHOP[1]

METHOD OF CONSTRUCTING, USE AND ADVANTAGES

BY F J. SCHLINK[2]

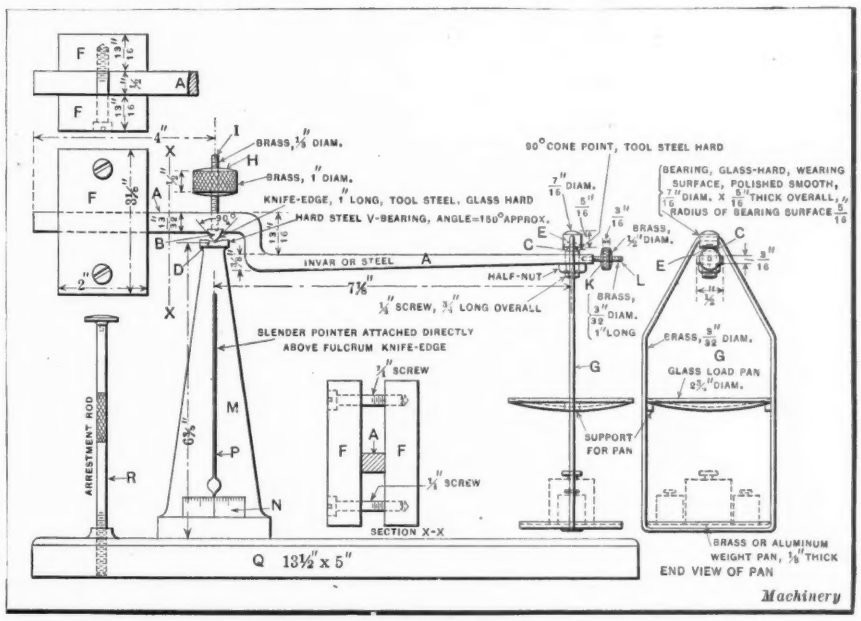
IT is often necessary, in the shop or engineering office, to weigh small quantities of materials with a rather high degree of precision, and yet the amount of work to be done may not be great enough to warrant the purchase of an analytical or similar balance. The price of an accurate, sensitive, chemical balance is rather high, and the theoretical and technical knowledge required for its manufacture precludes its being made successfully by anyone not expert in that line. The simple and inexpensive balance here described, however, can be made easily and at small cost, is easily adjusted, and will give satisfactory precision for such work as the weighing of small samples, moisture determinations, and a number of other uses for which an accurate balance of small capacity is required.

The beam *A* should be made of steel or invar; the latter, which is a comparatively inexpensive nickel-steel alloy, is preferable on account of its negligible coefficient of thermal expansion. If machinery steel is used, it should be carefully lacquered or enameled to prevent rusting. In the case shown, the beam is 1/2 inch wide; its short arm is 13/32 inch thick throughout, but its long arm tapers from 3/8 to 3/16 inch at its outer end. Its fulcrum *B* may be either two cone points spaced about an inch apart along a line perpendicular to the plane of the beam or a knife-edge an inch long. If the latter is used, which is the preferable form, it should be absolutely straight, and finished, by smooth grinding, to a clean, sharp edge having an included angle of approximately 90 degrees. The load pan is suspended from a cone pivot *C* at the end of the beam. Both the knife-edge *B*, if one is used at the fulcrum, and the cone pivot *C* should be made of tool steel, carefully hardened and ground; the cone pivot should be perfectly sharp and have an apex angle of approximately 90 degrees. The knife-edge, the cone, and their bearings must be glass-hard, and the wearing surfaces of the bearings must be polished smooth. The V-bearing *D* of the knife-edge has an approximate angle of 150 degrees and the cup bearing surface *E* of the cone pivot *C* has a radius of 5/16 inch. The utmost care must be taken in finishing the knife-edge, cone pivot, and bearings that co-act with them; the sensitiveness and accuracy to be obtained in the use of the balance depends more directly on these factors than on any other parts of the instrument. Both the knife-edge *B* and the cone pivot *C* should be set snugly and firmly into the beam *A*. For this purpose dowel pins or short screws may be used at the knife-edge.

A movable weight *F* is provided at the left side of the fulcrum to counterbalance the weight of the long arm of the beam and the load pan *G* at its end. It consists of two machine-steel blocks held in place by screws, which may be moved horizontally and vertically; its construction is shown by the top view and the section at X–X. As this weight is movable vertically, it is possible to increase the sensitiveness of the instrument by bringing the center of gravity of the loaded beam close to the knife-edge. This weight should be a neat fit on the arm on which it slides. After adjustment it should be tightly locked in place by the clamping screws shown. A finer adjustment may be obtained by means of the knurled nut *H* traveling on a fine threaded screw *I* immediately above the knife-edge *B*. The movement of this nut raises or lowers the center of gravity of the loaded beam in its relation to the knife-edge. The movement of the brass nut *K* that travels on the screw *L* inserted in the end of the beam is usually the only adjustment necessary when the balance is in use.

The pillar *M* that carries the hardened fulcrum bearing *D* should be firmly attached to the base of the balance. Near the bottom is placed a scale *N;* in the case shown, this has ten graduations, spaced 1/16 inch apart, on each side of the zero mark. The pointer *P* that travels over this scale is a slender rod that is attached directly above the knife-edge. The base *Q* may be made either of well seasoned, varnished wood or of a light hollow casting. The one requirement is that it shall be rigid and firm.

The load pan *G*, an end view of which is shown, carries both the load to be weighed and the set of weights. Its construction should be as light as practicable in order that the load on the cone pivot *C* may not be unnecessarily great. In the present case it is made of brass wire 3/32 inch diameter passing through a piece of hardened tool steel that acts as a bearing for the cone pivot *C*. The load to be weighed is placed on the upper tray and the weights on the lower. The upper tray may be flat or slightly concave; a large watch glass, about 2¾ inches in diameter, for instance, serves the purpose very well. At a convenient distance below is a brass or aluminum tray or rack, which carries the set of weights. This should provide for the arrangement of the weights in the order of their value.


BRASS, 1/16" DIAM.
BRASS, 1" DIAM.
KNIFE-EDGE, 1" LONG, TOOL STEEL, GLASS HARD
HARD STEEL V-BEARING, ANGLE=150° APPROX.
90° CONE POINT, TOOL STEEL HARD
BEARING, GLASS-HARD, WEARING SURFACE, POLISHED SMOOTH, 7/16" DIAM. X 5/16" THICK OVERALL, RADIUS OF BEARING SURFACE 5/16
BRASS, 1/2" DIAM.
INVAR OR STEEL
HALF-NUT
7 1/8"
1/4" SCREW, 3/4" LONG OVERALL
SLENDER POINTER ATTACHED DIRECTLY ABOVE FULCRUM KNIFE-EDGE
ARRESTMENT ROD
SECTION X-X
SUPPORT FOR PAN
GLASS LOAD PAN 2 3/4" DIAM.
BRASS OR ALUMINUM WEIGHT PAN, 1/8" THICK
END VIEW OF PAN
Q 13 1/2" x 5"
Machinery

Construction of a Simple and Accurate Balance

In order to protect the bearings, knife-edge, and cone from wear when the balance is not in use, an arrestment rod *R* is provided directly under the counterbalance weight *F*. This is a straight rod, with a flat cap at its upper end that is screwed into the base of the balance with a coarse-pitch thread. Turning the rod, by the knurled part, raises it into contact with the bottom of the counterbalance weight and lifts the latter so that the pan is brought down upon the base and the cone is relieved from contact with its bearing. When it is desired to use the balance, the rod is simply screwed down again so that it is no longer in contact with the beam.

The weight denominations should be so chosen that any weight value up to the weighing capacity of the balance can be determined. For example, if the weighing capacity of the instrument is to be about 0.5 pound—and a balance of this type will serve very well for that load—the set of weights may be the following decimal fractions of a pound: 0.2, 0.1, 0.1, 0.05, 0.02, 0.02, 0.01, 0.005, 0.002, 0.002, 0.001, 0.0005, 0.0002, 0.0002, 0.0001, 0.00005, 0.00002, 0.00002, 0.00001. For much of

[1] See also "Weighing-scales," in the January, 1916, number of MACHINERY.
[2] Assistant Physicist, Bureau of Standards, Washington, D. C.

the work for which a balance of this sort will be used, however, it will probably be advantageous to have weights in the metric system; in this case the weight set should include 100 grams to 10 milligrams, in the same 5–2–2–1 series. The weights should be handled with wooden or horn-tipped tweezers or pincettes. The Bureau of Standards will supply suitable specifications for weights of this sort if the inquirer will state the nature of the work for which they are to be used.

Adjusting and Using Balance

The adjustment of this balance, unlike that of the usual type of precision balance, is very simple, and consists of adjusting the position of the center of gravity of the loaded beam until it lies vertically below and very near the knife-edge line. This operation is performed in the following manner: After the parts are assembled, the weights are placed on the pan, and the whole brought into approximate equilibrium by moving the balancing weight *F* to the left or right as required. If the equilibrium is unstable, the center of gravity is too high, and may be lowered by lowering the balancing weight without changing its position in a horizontal direction. If, on the other hand, the balance oscillates quite rapidly, the center of gravity is too low, and may be changed by raising the balancing weight *F* without moving it horizontally. When the balance oscillates with a period of five seconds, or more, after the large balancing weight is securely clamped upon its stem, the final adjustment can be made with the adjusting nut *H* above the fulcrum. The occasional adjustment of the balance which may be required, in service, to cause the pointer *P* to oscillate about and come to rest at the zero of the graduated scale will be made by changing the position of the nut *K* at the right end of the beam.

To use the balance, bring it into equilibrium by turning the adjusting nut *K* at the right end of the beam until the pointer vibrates through equal distances on each side of the zero graduation. Then carefully place the object to be weighed in the upper tray and remove weights from the lower tray until the pointer again swings about the zero graduation. The sum of the values of the weights removed from the pan to produce equilibrium will be the weight of the object sought. (This method of weighing is called the method of substitution.) The value of the weight of the object should be recorded, the weights again placed in the lower tray, and the object weighed, removed; the pointer should again swing about the zero graduation, affording a check on the determination.

Care must be taken in the use of the balance to avoid all unnecessary shock and jar, thereby reducing the wear and dulling of the pivots. In addition, reasonable care should be taken to protect the balance from sudden and irregular changes of temperature, especially just before or during the time it is in use. The balance must also be carefully protected from dust and moisture, as these will cause rapid deterioration of any knife-edge or pivot.

If much careful work is to be done on the balance, it should be protected from dust and air currents, and to some extent from temperature disturbances, by a glass case. It will be impossible to weigh more closely than to about 1/5 grain (or 15 milligrams) on any balance in which the moving parts are not protected from air disturbances and radiation. A rider may be added to the beam to provide a more convenient method of determining the last figure or the last two figures of the weight. This is a modification that can be easily worked out to suit any particular case, as the rider scale is simply a uniformly divided linear scale, securely mounted on the beam, that carries a sliding weight the value of which will be adjusted by trial against a weight in the pan. The value of such weight is equal to the total interval of the rider scale.

Advantages of Balance

This type of balance has the advantage of ease of construction and adjustment. The common or so-called "equal-arm" balance has three knife-edges in the beam, and the accuracy of weighing depends on these knife-edges being constructed and maintained straight and parallel; also, if the balance is to be used in the usual manner, they must be spaced exactly equal distances apart. The satisfactory attainment of these conditions is a matter of great manufacturing difficulty and requires considerable skill and care. In balances for careful work, the spacing of these knife-edges will be adjusted to within one or two parts in one hundred thousand. In the highest grades of precision balances, such as are used for standardization work, equal spacing is sometimes attained to a precision of one part in a million, or less. This adjustment is obtained by almost infinitesimal shifts of the several knife-edges through a long and tedious process of trial and adjustment. The difficulty and expense of these adjustments will be readily appreciated.

In the balance here described, the knife-edge need only be straight and the cone point sharp and reasonably free from deformation under the load it carries. The effective length of the balance arm is always the perpendicular distance between the apex of the cone and the contact line of the knife-edge. This distance cannot change, as when three knife-edges are used, by the shifting of the point of resultant pressure along a knife-edge which is a trifle warped or out of parallel. (It should, however, be noted that for much work the cone pivot is not at all satisfactory; if the service is frequent and severe and the loads applied quite large, the high local stresses developed will cause rapid deterioration.) Another and very important advantage is that the sensitiveness of the balance is constant for all loads within its capacity, since the gross load carried by the beam is at all times constant during weighing.

With reasonable care, the balance should last a long time; but if after a period of use the cone pivot becomes dull, it is easily taken out and resharpened; at the same time the cup bearing should be repolished. When the pivot is replaced the balance is ready for use as soon as it is rebalanced to compensate for the changes which have been made in the weight of the parts by the repair. This easy repair, without the necessity of a complete realignment of parts, is a great advantage. The cone point when replaced should project the same distance from the beam as before, so that the balancing plane and sensitiveness will not be altered too much.

Results Obtained with Balance

An experimental balance of this type, made in accordance with the foregoing description in the instrument shop of the Bureau of Standards, showed a surprising precision and convenience. Its sensitiveness, as it was first adjusted, was so high that its readings were seriously affected by the slight air currents which prevailed in the room, although kept at a very nearly constant temperature and protected from drafts of every sort. It was necessary to remove the disturbing influences occasioned by the heat convection and radiation from the observer's body by reading it through a telescope mounted on a stand about five feet away. The readings then checked very well and weighings could be made and repeated within 0.006 grain (0.4 milligram, approximately). This difficulty due to air currents would have been practically eliminated, of course, had the balance been provided with the enclosing case usually supplied with balances used for accurate work.

Of course, for much work such precision is not required, and the balance can be adjusted to a lower sensitiveness and used in the open air, if reasonably well protected from drafts, serving even under these conditions a very useful purpose. However, for those who may wish to obtain the highest possible accuracy, the writer recommends the construction of a case of wood and glass, having a single sliding glass door in the front which can be opened for the removal and addition of weights. There is no reason, if this is done, why this balance will not perform as well, though perhaps lacking somewhat in convenience, as any analytical balances save those of very high grade and cost.

* * *

In 1892, vanadium was listed as the rarest metal and was valued at $4792 a pound, or twenty times as much as a pound of gold. The discovery of the rich deposits in the Peruvian Andes, 16,200 feet above sea level, in 1905, caused the value of vanadium to drop rapidly; it is now sold at $3.50 a pound. It is being used, however, much more extensively than formerly, and new uses are being constantly found.

ELECTRIC SEAM-WELDING[1]

METHODS OF JOINING SHEETS AND TUBES BY THE RESISTANCE WELDING PROCESS

BY DOUGLAS T. HAMILTON[2]

THE seam-welding of sheets and tubes is a process which is used quite extensively in the sheet metal industry, particularly in the manufacture of utensils which must be made with steam- or water-tight joints. There are two methods in use for making a joint by this process—one is to lap the joint and the other is to butt it. Tubing is usually butt-welded, whereas sheets are generally lap-welded. Seam-welding is extensively employed in the manufacture of tubing which is used in place of cold-drawn seamless tubing, as it is not so costly to manufacture. In making a seam or lap weld it is absolutely necessary that clean pickled stock be used in order to get the best results. When a copper roller is used, a slight amount of scale adhering to the rolls will produce a puncture when it comes in contact with the piece to be welded. In the following, several different methods and machines for making seam- and lap-welded joints will be illustrated and described.

Possibilities of Seam-welding

The art of seam-welding has not as yet reached the same stage of development as that of butt- or spot-welding, and hence very little practical data on this subject are available. As previously mentioned, this process is extensively employed in the manufacture of sheet metal utensils, tubing, etc. The Toledo Electric Welder Co., Cincinnati, Ohio, finds that this process can be commercially employed on sheet steel of 22 gage (0.0253 inch) and thinner. The stock is lapped for a distance equal to its thickness, and when the copper rolls pass over the lap, the metal is mashed down to the original thickness of the sheet. In order to avoid buckling and distortion, the material being welded should be clamped along the seam. It is difficult in some cases, however, to entirely prevent buckling, especially when the sheet is over 14 inches in length or greater than 22 gage in thickness.

Materials such as pickled mild steel, tin, terne plate and sheet brass are easily seam-welded. Zinc, aluminum and copper, however, are more difficult, and are not electric seam-welded on a commercial basis. In the case of utensils, such as coffee pots, pails, pans, etc., which require coating with enamel, this process is of considerable advantage. After the enamel is applied and the article baked, it is impossible to detect the seam.

[1] For information on electric welding previously published in MACHINERY, see "Electric Spot-welding Practice," September, 1916, and articles there referred to.

[2] Associate Editor of MACHINERY.

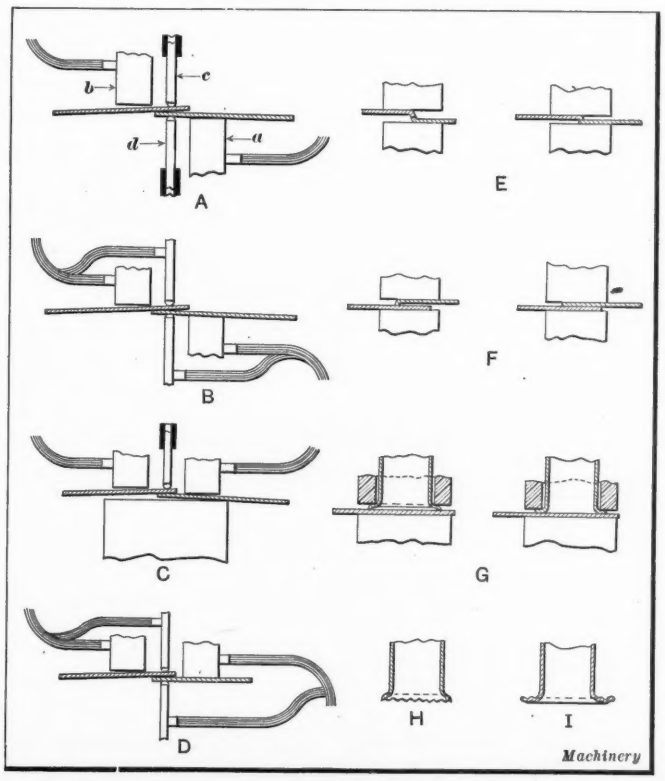


Fig. 1. Diagram illustrating Various Methods of accomplishing Lap-welding Operations on Spot-welding Machine

Fig. 2. Special Toledo Electric Seam Welder used principally for welding Teapot Spouts

Lap-welding on a Spot-welding Machine

For joining steel sheets which do not require a water- or steam-tight joint, a spot-welding machine can be employed by making certain modifications, depending on the character of the work and the class of weld desired. Several methods of accomplishing this work are illustrated in Fig. 1. When making a lap-welded joint by means of spot-welding in the ordinary manner, the welded spot generally covers so much surface as to distort the metal. In Fig. 1, *A* shows a method of avoiding this. Here two sheets are shown overlapping each other and resting on poles *a* and *b* which are connected to an electric circuit. Above and below the lapped joint are two punches *c* and *d* placed in line with each other and surrounded with insulating material. These are brought in contact with the sheets at the point where the weld is desired, and when the current is turned on it passes through the poles *a* and *b*, and is localized at the point where the two punches come in contact with the work. Fusion takes place at this point of resistance, and when the correct temperature is reached, the two punches are brought together, forcing the heated material into a coalescent mass.

A slightly different application of this method is shown at *B*. Here the current, in addition to passing through the two poles, also passes through the punches. This method is particularly suitable for welding comparatively thick sheets. *C* shows still another modification. In this case, a large lower anvil, not connected with the electric circuit, and two poles located in

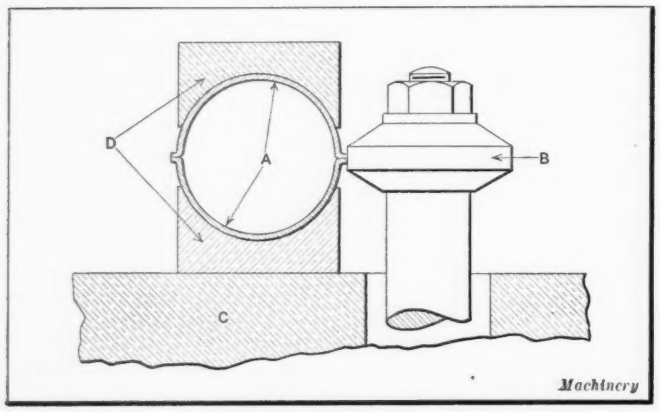


Fig. 3. Diagram showing Method of welding Teapot Spouts on Machine shown in Fig. 2

the same position are used. Only one punch is used, the required pressure being received on the lower anvil, and it is not connected with the electric circuit. A modification of the methods shown at *B* and *C* appears at *D*. In this case the two poles are also connected with the electric circuit.

Several other methods of accomplishing lap-welding operations on a spot-welding machine are shown at *E* to *H*. At *E* both sheets to be welded are bent over at the ends so as to localize the current. After the correct temperature has been reached, pressure is applied, resulting in a weld as shown at the right-hand view of the same illustration. Still another method is shown at *F*, in which only one strip has a turned-over edge. Here the welded junction takes place at a considerable distance from the edge of the strip. A method which can be used for welding a tube to a sheet is shown at *G*. In this

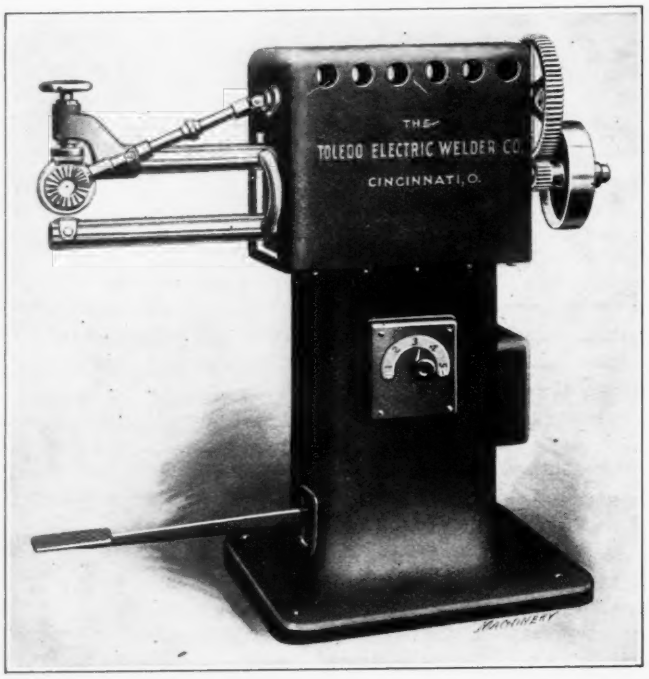


Fig. 4. Special Toledo Electric Seam Welder used for welding Sheet Steel of Light Gage

case the lower electrode is made flat and the upper electrode is in the form of a ring surrounding the tube as shown. The lower end of the tube is expanded, so that when heat and pressure are applied the lap-welded joint as shown at the right is produced. Two other methods of forming the lower end of a tube to be welded to a sheet are shown at *H* and *I*, the form shown at *H* giving what might be called a projection weld, and that shown at *I* giving a ridge weld.

Seam-welding Teapot Spouts

A special seam-welding machine used principally for welding kitchen utensils and similar work is shown in Fig. 2. This is a comparatively small machine, and is adapted particularly for welding teapot spouts. The diagram shown in Fig. 3 illustrates how this machine operates. The two halves of the spout *A* are stamped to the proper shape in a press and trimmed so that a slight projection is left extending from the edges as shown. One electrode of the machine is a copper roll *B*, mounted on a shaft that carries the current, rotating at 100 revolutions per minute. The other electrode is the top of the table *C* which carries the other side of the circuit.

In operation, the two halves of the spout *A* are clamped in copper die-holders *D*, and as these rest on the top of the copper table, the current passes through them, forming the second electrode. Therefore, when the edges of the spout are brought up against the copper roll *B* and passed before it, the thin metal in the edges is quickly fused and pressed down so that a smoothly finished surface is produced. The dies are then

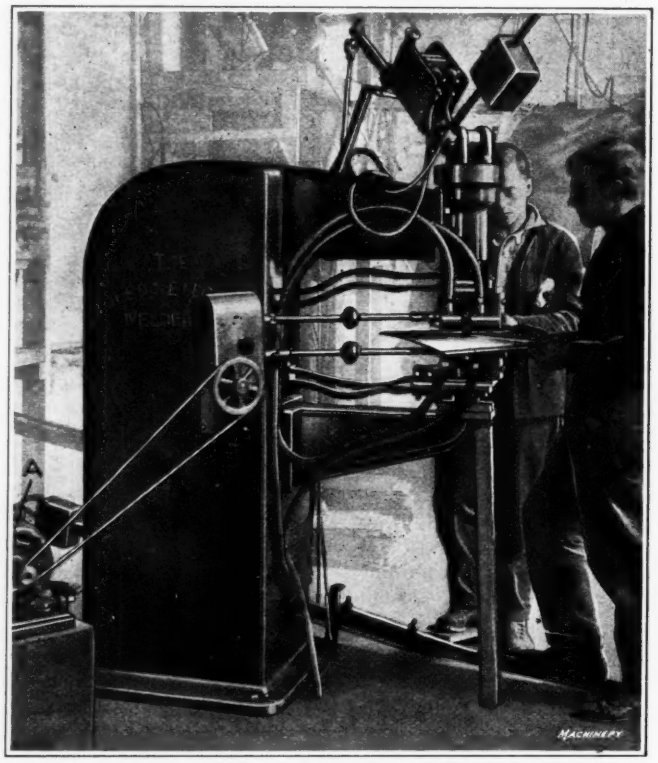


Fig. 5. Toledo Spot Welder especially fitted up for seam-welding

turned around, presenting the other edge or side of the spout to the roll, and the operation repeated. One boy can weld an average of 800 spouts in ten hours, and after the spout leaves the welding machine, it is ready for enameling. The machine shown in Fig. 2 is driven by a belt, the pulley rotating at 200 revolutions per minute. The maximum capacity is 5 kilowatts, or approximately 7½ horsepower.

Another seam-welding machine for welding sheet steel is shown in Fig. 4. This machine is also power-driven and can be used on various classes of light gage stock that is pickled and clean. The edges of the stock are made to overlap a distance equal to the thickness of the sheet, and are placed under a copper roll, which is mounted in an adjustable holder as shown. Pressure on the foot-treadle starts the machine, the current being automatically turned on and the stock carried through between the revolving rolls. As the stock emerges

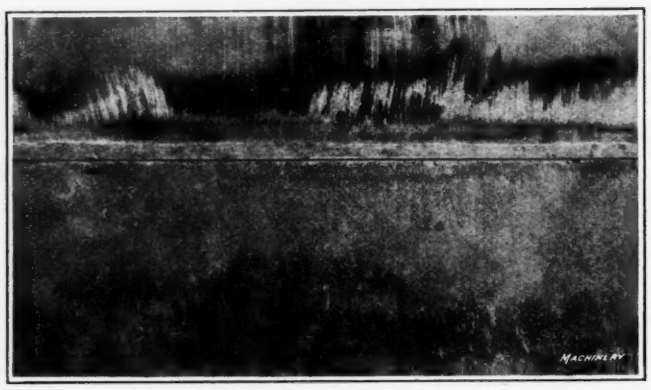


Fig. 6. Sample of Lap-welding accomplished on Machine shown in Fig. 5

from the rolls the current is automatically turned off. This machine cannot be used on galvanized iron or rusty and scaly sheet steel or iron. The upper roll is operated by power from a pulley at the rear through a flexible shaft and bevel gear and pinion at 100 revolutions per minute. The maximum thickness of stock that can be satisfactorily welded is 1/16 inch.

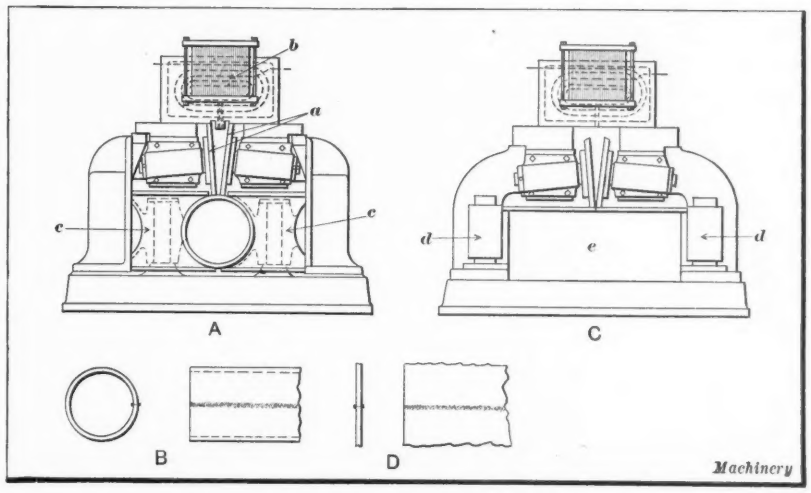


Fig. 7. Diagram illustrating Two Types of Butt Seam Welders built by the Thomson Electric Welding Co.

Spot-welding Machine Adapted for Lap-welding

In Fig. 5 is shown a Toledo electric welding machine fitted up for lap-welding sheet steel. The regular spot-welding electrode holders have been removed and special holders substituted. These holders are water-cooled and carry copper rolls which are driven by a flexible shaft from a two-horsepower motor *A*. The work to be welded is placed between the copper rolls, and the foot-treadle operated; the electric current is turned on at the same time, and as the sheets pass under the rolls they are heated and pressed together to form a weld. Fig. 6 shows a sample of lap-welding as accomplished on this machine. The joint, as will be noticed, is mashed down, but the sheets were under considerable tension and buckled to a considerable extent. The reason for this is that the local heating of the edges of the sheets causes them to stretch considerably, and hence buckle. In order to avoid this it is necessary to clamp the sheets close to the weld.

Special Machine for Electric Seam-welding Tubes and Sheets

Several different types of machines have been designed for seam-welding tubing. One of these, shown by the diagram at *A* in Fig. 7, is of comparatively simple construction. Its chief advantage is that the working terminals are located close to the turns of the secondary, so that the work is kept outside of the space enclosed by the conductor constituting the secondary of the transformer. The working terminals of the secondary of the transformer are copper disks *a*, which are located in such a position that the working faces converge toward the side farthest from the secondary *b*. These terminals are carried on axles which, in turn, are journaled in bearings located in such a position that disks *a* give a full bearing on the tubes to be welded. The tube is fed into the machine by rolls *c* as illustrated, being held in such a way that the seam is located equidistantly between the two copper electrode disks.

In operation, the welding current passes from one pole of the secondary through one of the disks *a*, then across the seam of the tube and through the adjacent edge of the tube to the other disk, and so back to the turns of the secondary, forming a complete circuit. With this machine a continuous traveling weld is made, as shown at *B*.

A seam-welding machine embodying the principles illustrated by the diagram at *A* in Fig. 7 is shown in Fig. 8. In this case the feeding rolls, which are located in a horizontal instead of in a vertical position, have been dismantled to show the construction. The pressure rolls are located directly beneath the electrode disks, and supply pressure to butt the edges of the tube together. This machine is provided with an oil transformer, and the working terminals are outside the magnetic field. The machine is adapted for welding sheet steel edge to edge to make tubing up to 2 inches diameter with 1/8 inch thickness of wall. The speed of welding is from 20 to 30 feet per minute.

A modification of the machine shown at *A* in Fig. 7 is shown at *C* in the same illustration. In this case the machine is adapted for seam-welding flat sheets. The only change is the elimination of the rolls *c* for applying pressure to the tubing and the substitution of small rolls *d* and a flat table *e*. Rolls *d* press the abutting edges of the work together, and at the same time feed it past the welding electrode disks. A weld made in this machine is shown at *D*.

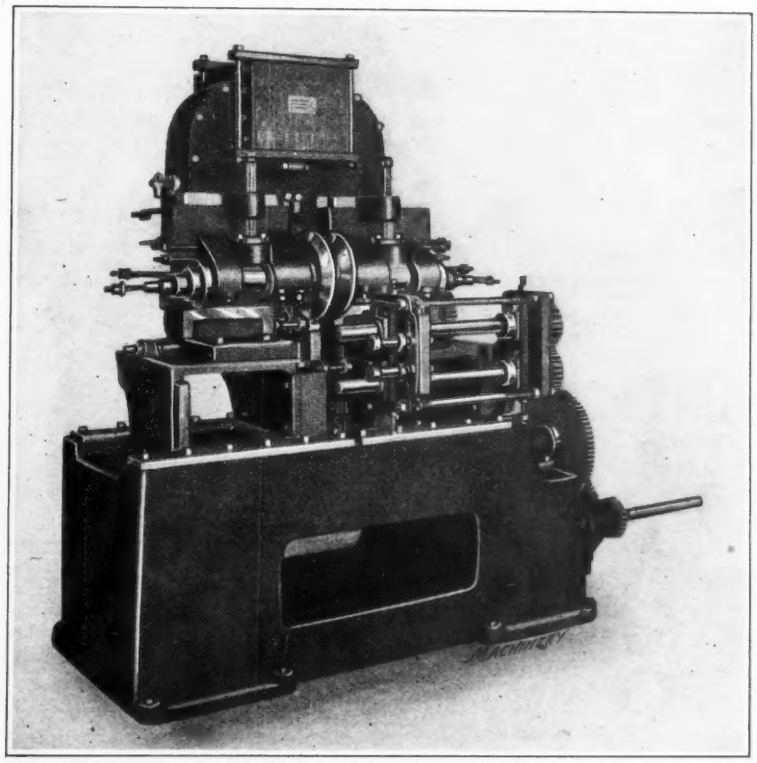


Fig. 8. Special Butt Seam Welder built by the Thomson Electric Welding Co. for seam-welding Tubing at the Rate of 20 to 30 Feet per Minute

Special Machine for Lap-welding

Fig. 9 shows a special seam welder which is employed principally for lap-welding coffee pots and similar articles. This machine, as shown by the diagram, Fig. 10, has one disk electrode *A* which is used for carrying one side of the current and applying pressure, and a horn *B* with a copper strip *C*, which forms the other side of the circuit. The work to be welded is placed on horn *B* with the joint lapped, as shown. The machine is then started by operating one of the foot-treadles shown in Fig. 9, and the welding commences. The platen carrying the horn is driven forward by power at the rate of 25 feet per minute and is returned by operating the handwheel shown at the front of the machine. The maximum length that can be welded in this machine is 12 inches.

Manufacturing Seam-welded Tubing

As has been previously mentioned, tubing is made by several different processes. One method is to pierce a heated billet, and then by successive redrawing operations form this into a tube of the required length and diameter. Another method is to roll out sheet metal into the form of a skelp, then bend it up into a tube and electrically or

autogenously weld the seam where the two edges meet, either in the form of a lap or a butt weld. The third method, and the one which will be described in detail here, is to take the heated skelp directly from the furnace and weld it electrically without any additional heating or annealing. This method has been patented by Elias E. Ries, and makes use of a rolling machine in connection with a series of electrodes for uniting the heated skelp; the original heat remains in the skelp after

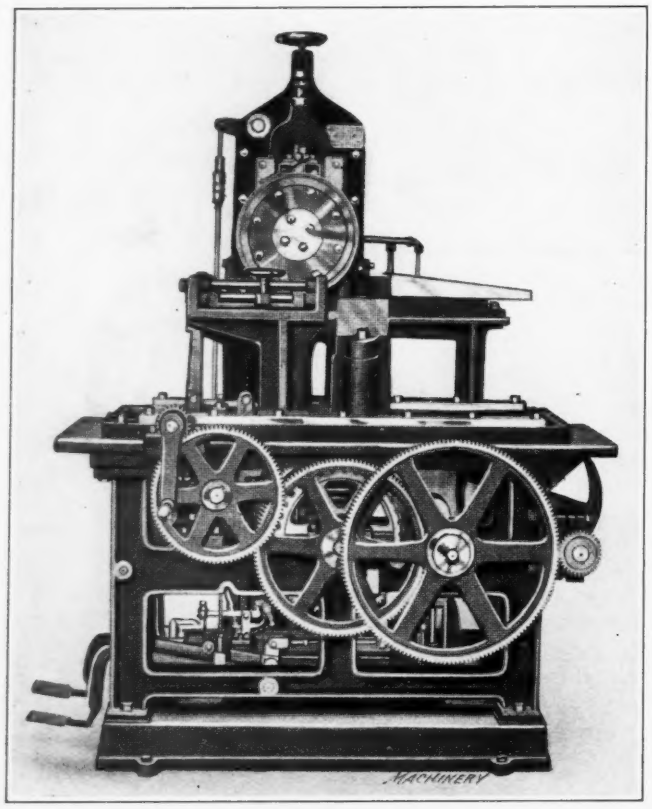


Fig. 9. Special Thomson Electric Seam Welder used principally for lap-welding Coffee Pots, etc.

it leaves the furnace, being increased to such a point that fusion between the edges of the tubing is possible.

The diagram shown at *A*, Fig. 11, illustrates in a general way this process of manufacturing tubing. Referring to the illustration, *a* represents the bull-head or skelp finishing mill, *b* and *c* the skelp bending rolls, and *m* the guiding bell through

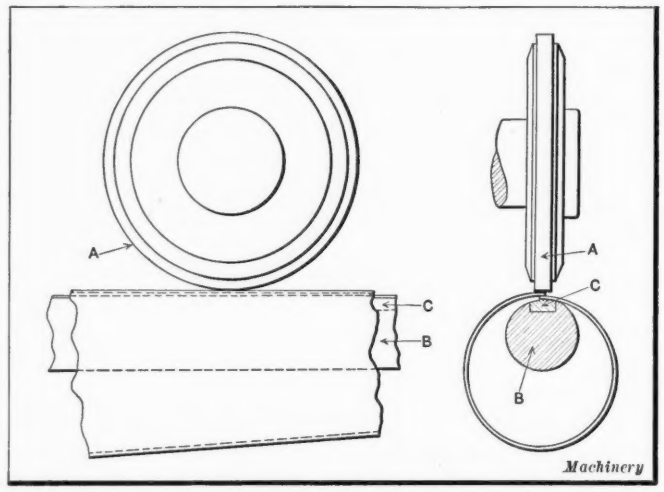


Fig. 10. Diagram illustrating Method of lap-welding Coffee Pots on Machine shown in Fig. 9

which the bent skelp is fed into the several sets of current conducting shoes or contact rollers; each set consists of a number of upper contactors *d* that are in electrical connection with one pole of the heating circuit; also two side bearing contactors or rolls *e* that are in electrical connection with the opposite pole of the heating circuits. The secondary terminals of the heating transformers *f* are connected with the contactors *d* and *e* through the insulated roll-supporting framework mounted on the cover of the transformers, the sets of contactors for each transformer being connected in parallel. Another guiding bell is shown at *g* that has a tapering throat which brings the highly heated edges of the partially opened skelp toward each other or in contact so as to close it into tubular form preparatory to welding by rolls *h*. Between these rolls passes a mandrel *i* shown at *B* supporting the skelp. The welded tube passes directly from the rolls *h* to the finishing and reducing rolls *k*, which have a smaller mandrel *l*. The rolls *k* give a higher finish, and practically produce a seamless drawn tube from the welded pipe.

Another adaptation of this method of electric welding is shown at *C*, where it will be seen that a series of electrodes form an electric arc and are arranged in tandem along the meeting edges of the tubular skelp. The current passing through these electrodes is independently adjustable by means of a special resistance, and the skelp, when properly heated, is welded in its passage through the welding bell *n* which

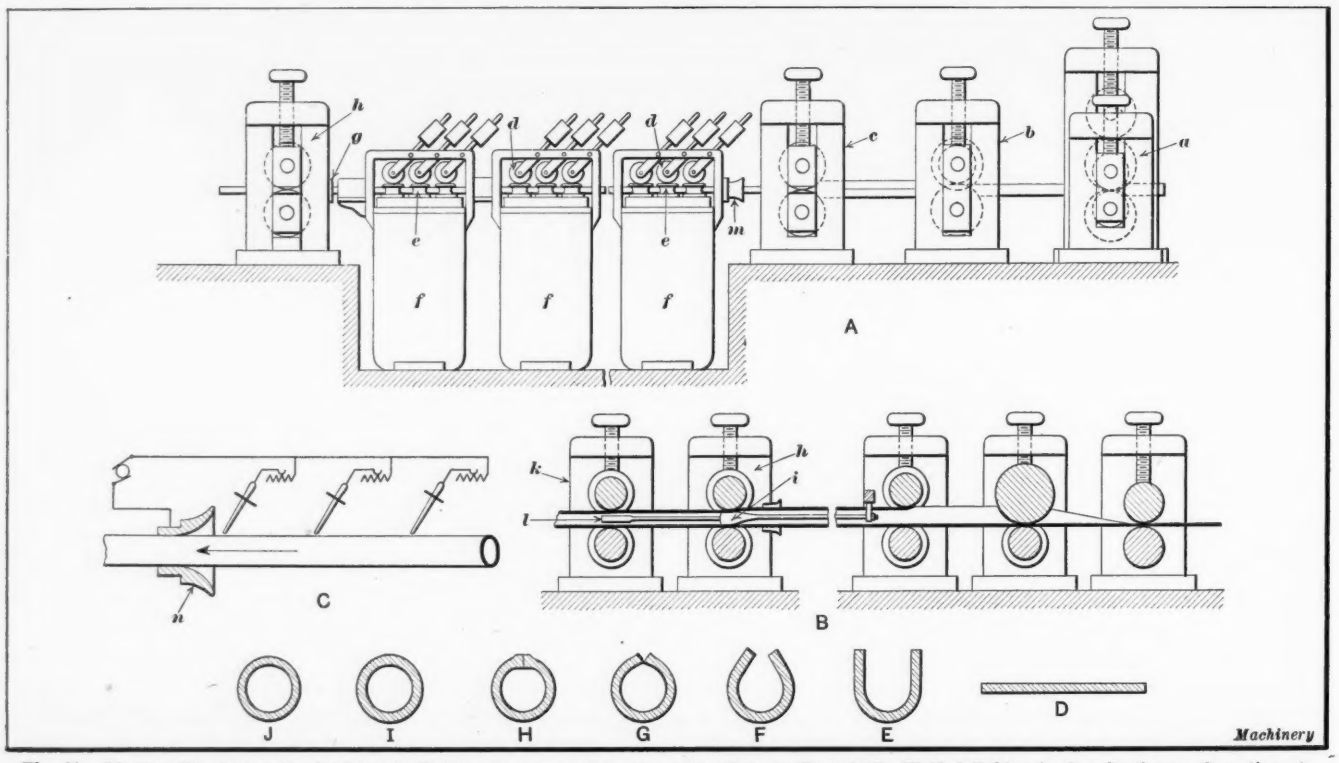


Fig. 11. Diagram illustrating Special Electric Welding Process used in converting Skelp to Electrically Welded Tubing in One Continuous Operation at the Rate of 400 Feet per Minute

constitutes the opposite terminal of the heating generator. The longitudinal movement of the frame carrying the electrodes can be varied so as to alternately increase or diminish the heating effect on the metal, depending upon whether the arc travels with or against the direction of the travel of the skelp. By arranging the heating electrodes in this manner, overheating and burning of the skelp is avoided.

The views from *D* to *J*, inclusive, show the sequence of operations performed to convert the material from skelp to tube form. The skelp leaves the furnace at a white heat, and after passing through the various operations up to point *F*, will be found to still retain a temperature varying between 2100 and 2200 degrees F. This residual heat represents about four-fifths of the heat required for welding, so that the heat which it is necessary to add to the abutting edges of the tubular skelp is only about one-fifth of the total. In other words, to weld the hot traveling skelp, the transformers are called upon to develop on the edges of the skelp a temperature of 500 to 550 degrees F. Usually the skelp travels at the rate of about 6 feet per second, but by this method it has been found practical to weld skelp at rolling speeds, averaging 400 feet per minute. Continuous lengths of tubing 60 feet in length have been electrically heated and welded in from nine to ten seconds.

* * *

BREAKING STEEL BARS WITHOUT WASTE OF METAL

A United States patent has been granted to P. V. L. Bellanger, of Paris, France, for a quick method of breaking steel bars without waste of metal. By this process the cross-section where the bar is to be broken is submitted momentarily to the action of a blowpipe flame which may be oxidizing and which has a temperature of about 700 degrees C. The bar is then placed on two supports and a sharp tool is applied by pressure, or a blow is struck opposite the affected part of the bar; in either case, a clean, square break is produced without tearing or wasting the metal. The blowpipe flame should have the shape of a lance-head and should be applied normal to the length of the bar, so only the point acts on the metal. The flame action renders the metal brittle in an extremely narrow zone, so that the bar can be broken cleanly without the metal being harmed.

* * *

Experiments conducted by the British Committee of the Ministry of Munitions fully justify the recommendations of the committee that a week's work, for men, should not exceed 65 to 67 hours; and for women, 60 hours. They also show that for many cases less hours give better results. In the case of boys between 14 and 17 years of age working on steel base plugs, the hourly output was increased 16 per cent after the Christmas holidays, and later, when the hours of labor were reduced from 70.3 to 57 per week, the output was increased 19 per cent.

GRADUATING GEAR SHAPER DIALS ON THE GEAR SHAPER

BY JOHN G. BRUEGGEMAN[1]

The extreme accuracy of the indexing mechanism of the Fellows gear shaper in connection with the cutting of gears is well known. It is perhaps not generally appreciated, however, that this feature of the machine adapts it to the accurate graduating of dials, etc. The writer of "Graduating on the Gear Shaper," in the October number of MACHINERY, has shown that the Cleveland Machine Tool Co. is using this machine for graduating circles. This practice is also in use in the shops of the Fellows Gear Shaper Co. where two of its own dials are graduated on the gear shaper. These are the dial for setting for depth of tooth and the small micrometer dial on the lead-screw.

Graduating the pitch depth dial is a particularly interesting example of what can be done on the gear shaper in the way of indexing. It also illustrates the adaptability of the gear shaper cutter and the gear shaper molding-generating principle. The dial, instead of being graduated in thousandths of an inch, reads directly for the gear pitch desired. This makes the graduations irregular, and in consequence, when indexing in the usual way with the milling-machine dividing head, errors are likely to creep in.

Fig. 1 shows the depth dial (integral with the dial gear) and the graduating cutter mounted in position on the machine. At *M* is shown, also, the micrometer dial. Fig. 2 is a view of the top face of the cutter and shows the spacing of the teeth. This cutter is made the same diameter as the dial and the two roll together like two friction rolls —the same as the cutter and the gear in gear cutting. Consequently, the spacing of the graduations on the rim of the dial corresponds to the spacing of the teeth on the cutter. Fig. 2 shows also how the graduations are marked in terms of gear pitches (diametral) instead of in thousandths of an inch. With this marking, the operator has only to set the dial to the pitch number, and the machine automatically feeds the cutter in to the correct depth for a tooth of that pitch. It will be seen that the cutter and dial are set up on the machine in the same way as are the cutter and work when cutting gears. They are aligned by means of the block *B* and the slot in the rim of the dial; this alignment is necessary to prevent a graduation from falling in the space occupied by the slot. One revolution of the cutter and work completes the operation. The time for graduating the dial by this method is three minutes; using the milling-machine dividing head, the job took fifteen minutes. In making the cutter, the blank was slotted on the milling machine with the arrangement formerly used for indexing the dials. The proper spacing of the teeth was determined by means of very simple calculations.

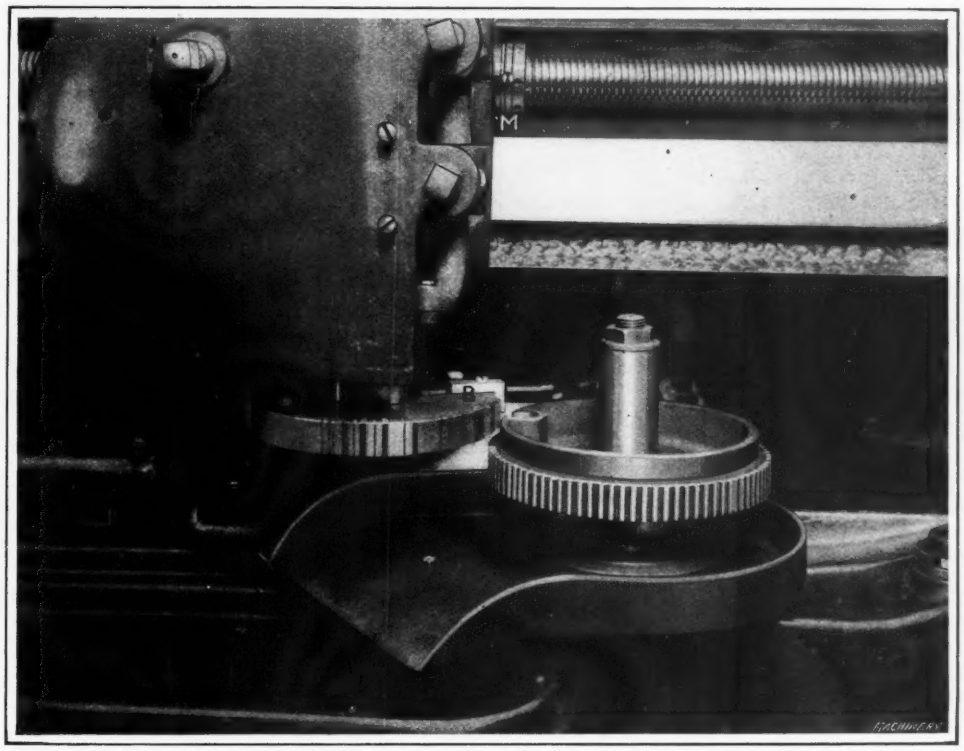


Fig. 1. Depth Dial and Cutter used for graduating

In use, the dial is mounted on the lead-screw, the lead of

[1]Address: Springfield High School, Springfield, Vt.

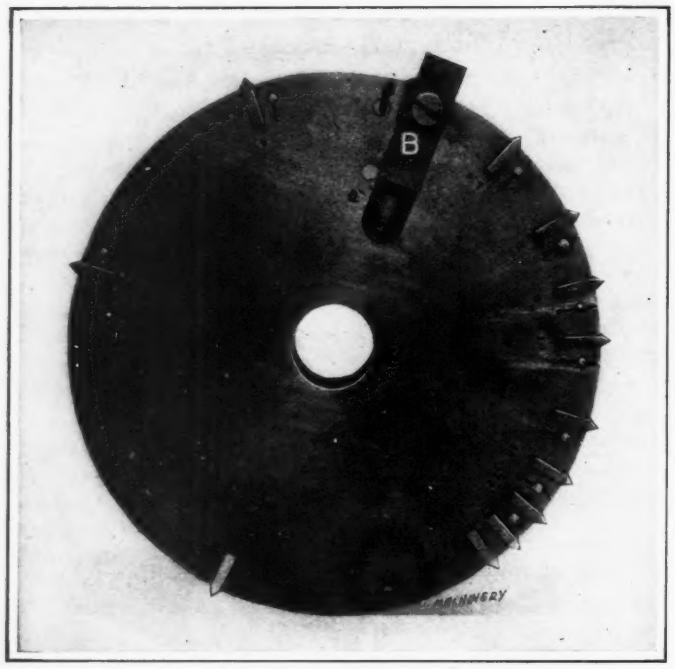


Fig. 2. Top of Cutter showing Spacing of Cutter Teeth

which is 1 1/3 turn per inch. One revolution then means 0.750 inch travel of the saddle; or, 0.001 inch travel of the saddle corresponds to 1/750 revolution of the dial. With forty teeth on the worm-wheel in the index-head, 1/750 revolution of the work means 40/750 revolution of the crank-pin in the index-head. Then using a seventy-five-hole row in the index-plate, indexing four holes will give a motion of the dial which would correspond to 0.001 inch travel of the gear-shaper saddle. Knowing the depth of tooth, in thousandths of an inch for the first gear pitch, say twenty, the number of holes to index is found by multiplying the four holes by the depth of a twenty-pitch gear tooth; for the second pitch, say eighteen, by multiplying by the difference between the depth of tooth for the eighteen-pitch and the twenty-pitch and so on. Graduating for metric cutters is done by the same method. This requires, of course, a differently spaced graduating cutter. In special cases, where both the English and the metric graduations are put on the same dial, the graduating is done in two operations, using the English and then the metric cutter, with one setting of the work.

Fig. 3 shows the micrometer dial, and the cutter with which this graduating is done. This job differs but little from the one described in the article previously referred to, except in the construction of the cutter. To get the different lengths of graduations, instead of making the cutter solid and grinding the teeth to different lengths, the cutter was constructed with each different length of tooth on a separate piece. The three pieces were then assembled and aligned with a pin driven through them. The method of mounting the cutter and work, and of cutting the graduations is similar to the method described in the preceding and in the article on graduating with the gear shaper referred to. The time for this job is four minutes.

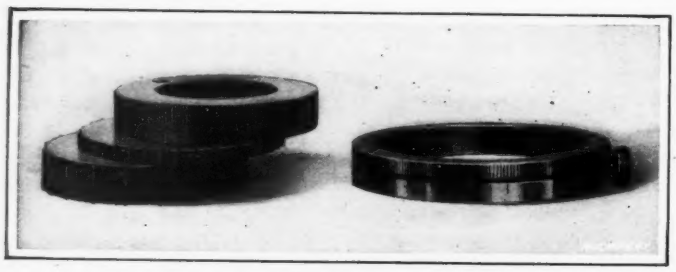


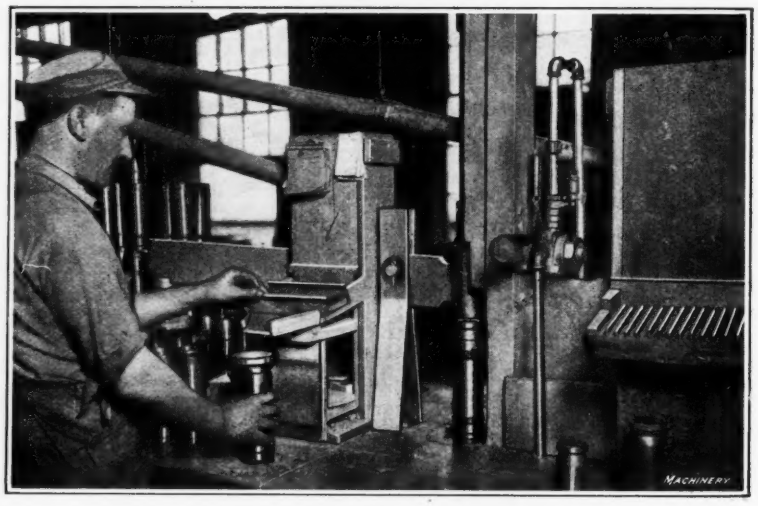
Fig. 3. Micrometer Dial and Cutter used for graduating

SHRAPNEL BALL COUNTER

At the Vermont Farm Machine Co.'s plant, Bellows Falls, Vt., the loading of 3-inch Russian shrapnel with ½-inch balls is done in two operations. In the first operation, ninety of the balls are dropped into the shrapnel case, and are then submitted to a three-ton pressure to pack them down. The second operation consists of dropping 150 additional balls into the shrapnel case, sprinkling in a charge of smoke making powder, weighing and adding enough balls to attain the exact weight required and then pressing with a three-ton pressure.

The improvised counting machine shown herewith has worked out very satisfactorily at this plant for inserting the correct number of balls in the shrapnel case with two pressings, which seems to be the advisable practice. The counting machine to the left which the operator is using consists principally of a storage chamber fed by an inclined pipe from a large tank near the ceiling. Opening from the bottom of the small retaining tank is an inclined raceway which is divided into ten channels. There are two gates which are spaced approximately nine ball diameters apart.

In operation, the workman lifts the upper gate, nearest the tank, which causes ninety balls to roll forward, stopping against the front gate. He then replaces the rear gate and lifts the forward gate, as shown in the illustration, releasing the ninety balls which drop into the shrapnel case. During the process the shrapnel case is being shaken up and down by a jogging device on which it rests. The partially filled case then passes to the hydraulic press at the right of the operator, where the three-ton pressure is applied. It then goes to the counting machine shown at the extreme right of the illustration, where 150 balls are added. This machine has fifteen raceways and is constructed to space off ten balls between the gates. These counting machines might have been made to count out 100 balls for the first pressing and 140 for the second or any other combination, but the one used was considered advisable and worked out satisfactorily. Though these devices were more or less makeshift, they have proved very effective in getting out a large quantity of work, and the principles involved are simple but ingenious. V. B.



Shrapnel Ball Counting Machines and Hydraulic Press

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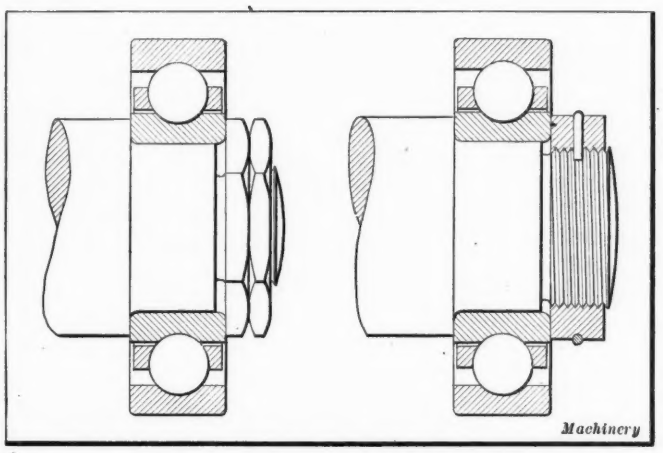
S. A. E. SCREW THREAD STANDARDS CHANGE

The Society of Automobile Engineers has issued a revision of the S. A. E. standard screws and nuts in respect to the threaded portion of the bolt. The length of effective thread now specified is $D \times 1.5 + \frac{1}{4}$ inch, in which D is the diameter of bolt in inches. The length of the thread previously specified was $D \times 1.5$, but it was found that the bolt makers were prone to make the effective threaded portion too short, measuring the thread to the extreme point that had been marked by the die; hence the length of the threaded portion was increased by ¼ inch on all sizes.

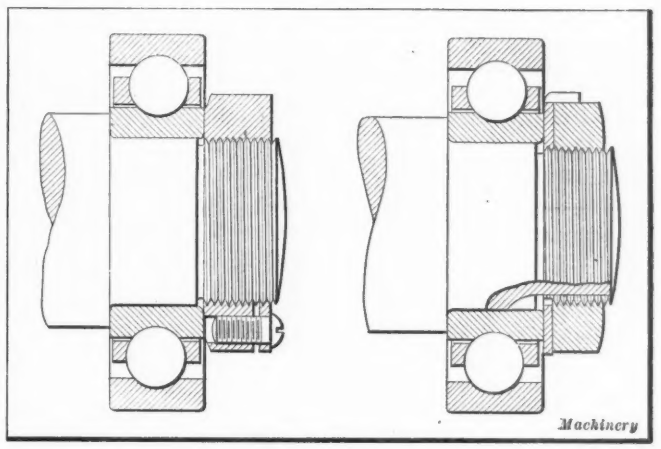
USING BALL BEARINGS[1]

CARE, STORING, HANDLING AND MOUNTING

BY OTTO BRUENAUER[2]



Figs. 1 and 2. Simple Mountings of Straight-bore Bearings on Straight Shafts, showing Means of locking Nut



Figs. 3 and 4. Alternative Methods of locking Nut to clamp Ball Bearings on Straight Shafts

A BALL bearing is a piece of mechanism of extraordinary precision and accuracy. The balls and races are truly spherical and circular, respectively, within a fraction of a thousandth of an inch, and the balls are fitted between the races with equal accuracy. A speck of dirt in the raceways will give a sensation when the hand spins the bearing as if the balls were rolling over a big lump. Dirt and grit in a bearing or rough and careless treatment affect its running qualities and ultimate wear in the same way as they would the works of a watch. No man would ever think of letting his watch with the case open lie around on dirty work benches or on the floor of the shop. Yet he will do this with a ball bearing, giving it every possible opportunity to become filled with foreign matter, and otherwise abuse it to the detriment of its life and usefulness.

Because of ignorance of conditions and lack of proper methods in handling ball bearings before and during the process of mounting many ball bearing installations have been failures. They were rendered useless before they were put into operation. No matter how carefully and correctly the design has been worked out by the engineer his best efforts are likely to be defeated by careless or improper methods of handling the bearings in the shop. The one must supplement the other, and it is with this correlation in mind that the handling, mounting and lubrication of ball bearings are dealt with in the following. Many of the directions are intended particularly for large quantities of bearings. However, the general principles of cleanliness and carefulness apply wherever ball bearings are used, regardless of the quantity or the size of the shop. The details of the method alone may be varied to suit conditions, and of course will be less elaborate in a factory which uses but few ball bearings.

STORING AND HANDLING

When taking the bearings out of the shipping cases the individual boxes in which they are packed must not be opened. The unpacking should be done on tables rather than on the floor of the receiving room, and the shipment after being checked should be sent to the store-room immediately. If trucks are used for this purpose other material should not be piled on top of the bearing boxes, as this is likely to damage the bearings. If the individual boxes and wrappers in which the bearings are packed by the manufacturer remain intact, the bearings may be stored and kept almost indefinitely. They are slushed and well protected from danger of rusting and should not be unwrapped or handled in any way until ready for use. Each box is distinctly marked with the number and type of bearing it contains. Thus, it is an easy matter to store them neatly on shelves, arranged by numbers and types.

Used bearings should not be stored without careful inspection. Frequently bearings are delivered to the store-room that have been used in some way or other in the assembling department or that have been taken out of dismantled machines. It should be made a strict rule that no such bearings may be stored without having been washed, inspected, slushed and

[1] The following articles relating to the care, use, design, construction, manufacture and application of ball bearings have previously been published in MACHINERY: "Lubrication of Ball Bearings," July, 1915; Ball Bearings," June, 1915; "Pitch Diameters of Ball Bearings," January, 1915; "Load Capacity of Ball Bearings," May, 1914; "Sliding Action in Ball Bearings," April, 1914; "Formula for Determining the Ball Circle Diameter for Ball Bearings," September, 1913; "Ball Bearings—Their Construction and Application," July, 1913; "Making Annular Bearings," December, 1912; "Making New Departure Ball Bearings," November, 1912; "Ball and Roller Journal Bearings," September, 1912; "Ball and Roller Thrust Bearings," August, 1912; "Some Tools used in the Manufacture of Small Steel Balls," August, 1912; "The Mounting of Ball Bearings," July, 1912; "The Manufacture of Steel Balls," February, March and April, 1912; "Use of Ball or Roller Bearings in Machine Tool Construction," November, 1910; "Some Notes on Ball Bearings," May, 1909; "Ball Bearings," December, 1907, and January, 1908; "A New System for Manufacture of Steel Balls," November, 1900; "Ball Bearings," July, 1900.

[2] General Sales Manager, Gurney Ball Bearing Co., Jamestown, N. Y.

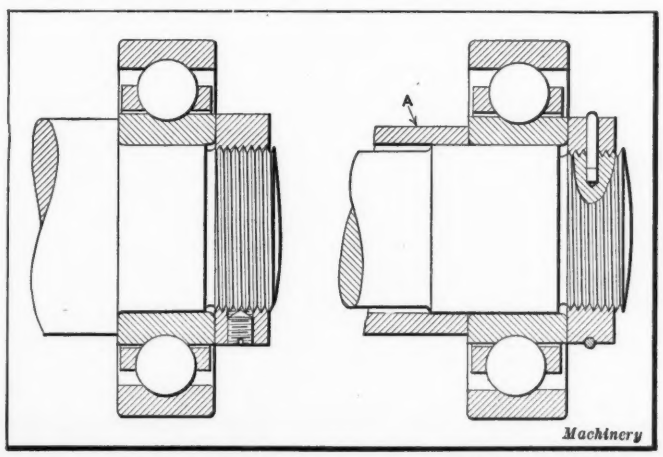
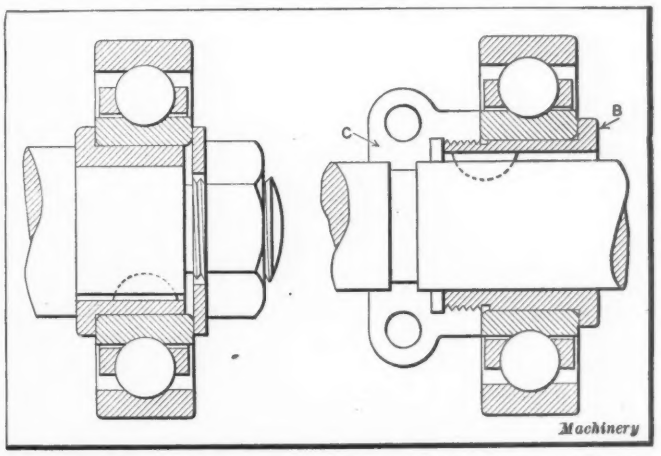


Fig. 5. Another Ball Bearing Mounting held by Nut

Fig. 6. Ball Bearing Mounting utilizing Spacer Ring



Figs. 7 and 8. Methods of mounting Bearing with Bore Same as or Larger than Diameter of Shaft

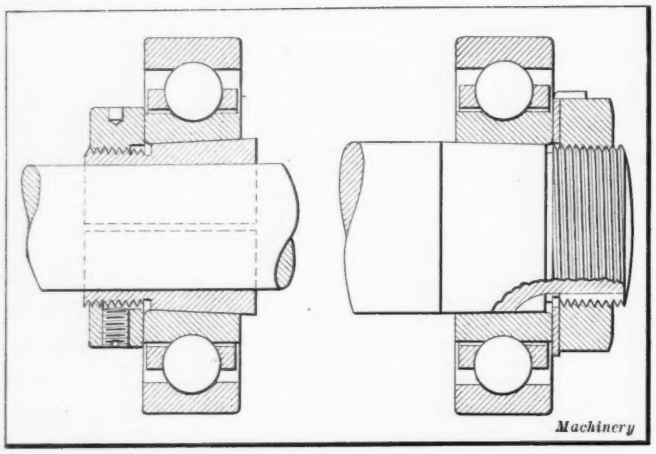


Fig. 9. Use of Adapter for mounting Bearings on Shafts that must remain Cylindrical

Fig. 10. Unsatisfactory Method of mounting Bearing on Tapered Shaft

repacked. In other words, they should be put in the same condition as a new bearing. To accomplish this, wash them in fresh gasoline, making sure that the pan is perfectly clean. The work bench or table on which this is done should be covered with paper or preferably lined with sheet metal, which must be kept clean. The best way of washing the bearing is to stick the fingers of one hand into the bore of the inner ring, and with the other hand spin the outer ring, and then quickly submerge the bearing in the gasoline. Bearings that are full of old or gummy grease should soak in the gasoline until the grease is dissolved. Dirt or grit will make the bearing run rough. In most cases repeated washing and spinning are necessary to remove these foreign matters. If they cannot be entirely washed out the bearings should be rejected.

If compressed air is available it may be used to advantage in cleaning bearings that have become full of dirt. After the bearing has been dipped in gasoline its inner ring should be driven by a tapered mandrel rotating at fair speed. One hand holds the outer ring stationary, the other applies the air blast. Repeated blowing of this kind will clean almost any bearing. Care should be taken, however, to have the compressed air clean and free from water.

Immediately after washing dip the bearing in kerosene to prevent rusting. Inspect it carefully. Make sure that the inner ring has not been cracked by driving it onto an over-size shaft, and that the ball separator has not been damaged by carelessly hitting it with a tool in driving the bearing on or off the shaft. If it is in good condition dip in a vaseline slush which will not gum up. Wrap in paraffine paper and place the bearing in its box. If a box is not available a heavy paper can be used. The bearing may now be stored again.

Bearings rejected by the inspector should be lubricated and repacked at once. If the inspector for any reason rejects part of a shipment of bearings they should not be allowed to lie around on benches, on the floor, or any place where they may rust or become dirty or wet. It is not fair to expect the manufacturer to accept a return shipment of new bearings which have been allowed to become dirty or covered with rust. The same cleanliness and care should be applied in such case as if the bearings were to be kept and paid for.

Before the bearing is mounted it must be washed in gasoline to remove the slush. If this is done in the assembling department a sufficiently large part of the work bench or a table should be used which is lined with galvanized or tinned sheet metal. A table with a metal lined basin sunk into its platform which may be covered up flush is a very good arrangement. The basin should have a drain however. When the mounting of bearings on shafts or spindles is done in one department and when the quantity of bearings warrants it, the washing should be done in a separate room and away from the work bench, preferably in the store-room or inspection department. Immediately after washing, the bearings should be dipped in kerosene. If this is not done they will dry quickly and have no protection against rusting. Dry bearings, if handled by perspiring hands, will soon rust, regardless of the amount of oil or grease with which they are lubricated afterward. It is difficult and often impossible to remove a bearing which has become rusted onto a shaft or into a housing. For this reason, as well as to keep the bearings clean, the assemblers should wash their hands freely in kerosene. Otherwise chips or filings sticking on their hands can easily enter into the bearing at the last minute and ruin it in a short time.

Under no conditions should a man be permitted to throw bearings around on a work bench full of tools, chips, sawdust, etc., or to throw them or let them lie around on the floor of the shop. Provide suitable equipment such as described and strictly enforce its use. A bearing with a chip or dirt in it will prove a very expensive thing to put into a machine, and any such neglect on the part of the workmen should be considered just as inexcusable as the dropping of a monkey wrench into a gear-box.

The washed and dipped bearings are best handed out to the assemblers in metal boxes. These may be provided with upright pins on which the bearings are stacked. A sufficient number of the various sizes required for a certain number of jobs may thus be handed out. The boxes can be kept close to the work when assembling and are a good protection for the bearings. If such boxes are used, it is well to leave a spare pin for each stack. Thus, when a man tries a number of bearings for the best fit, he can replace them on this pin instead of having to lay them temporarily on the bench or floor. The assembling department for reasons outlined above should be removed from the grinding department and located in a room which is unlikely to become filled with dust of any kind. Cleanliness should be the watchword.

When assembling transmission cases it is frequently customary to "run in" noisy gears with a grease which is mixed with some kind of abrasive. If this is done a special set of bearings must be used for this purpose only. Remove them afterward, wash case, gears and shafts thoroughly, blow them out, and remount the shafts on new bearings. Grease loaded with fillers such as sawdust, ground cork, etc., for the purpose of deadening the sound of gears is extremely injurious to ball bearings and must not be used.

Don't try to save by using grease or oil which has been used before. When the bearings are assembled in their places and ready for lubrication, fresh lubricant should be available. Aside from the reduced lubricating qualities of used oil or grease there is danger of their containing dirt or foreign matter.

Don't pack bearings between sawdust, excelsior, straw, etc. When bearings are to be shipped from one plant to another they should be carefully packed in strong cases. Under no circumstances should excelsior, sawdust, or similar material be used as a filler. The paper boxes in which the individual bearings are packed may break or open up because of rough treatment in transit and in consequence the bearings will become full of sawdust, etc.

MOUNTING BALL BEARINGS ON SHAFTS

The inner ring of a ball bearing must have a firm seat on the shaft. A press or force fit is often considered sufficient to

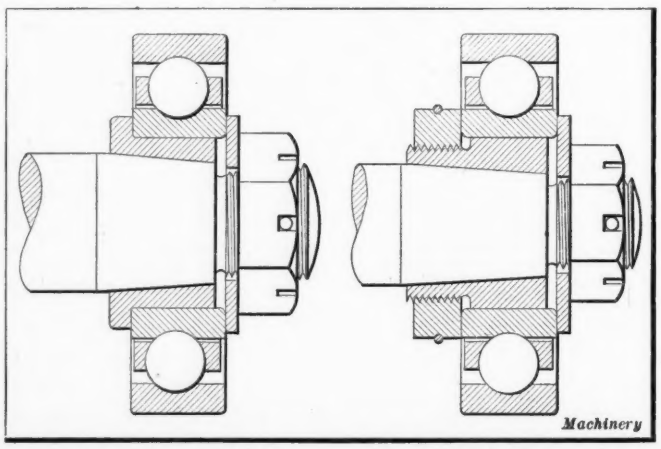


Fig. 11. Preferable Method of mounting Bearing on Tapered Shaft

Fig. 12. Method of mounting Bearing that gives Accurate Sidewise Location

mount a ball bearing properly on a shaft. However, if this bearing is once pulled off its seat and driven on again, there will be enough metal rubbed off the shaft to materially reduce its diameter. The bearing, when replaced, will have a more or less loose fit and will at once begin to peen down the shaft under the vibration of the varying loads, and thus gradually bring about abrasion of the shaft. A press fit is further objectionable for the reason that if not applied judiciously a stretching of the inner ring of the bearing, particularly of the light series, and a consequent tightening of the bearing, may result. Sometimes the inner ring will be stretched to such an extent that it will crack.

BORE AND SHAFT TOLERANCES FOR MOUNTING BALL BEARINGS

Bore of Bearings, Millimeters			Limits of Variations of Bore, Inches		Limits on Shafts if Race is Clamped between Shoulders	Limits on Shafts if Race is not Clamped between Shoulders
Light Series	Medium Series	Heavy Series	Plus	Minus		
10 to 20			0.0002	0.0004	+0.0000 −0.0005	+0.0002 −0.0003
25 to 80	20 to 65	20 to 55	0.0002	0.0006	+0.0000 −0.0008	+0.0003 −0.0004
85 to 110	70 to 110	60 to 110	0.0002	0.0007	+0.0000 −0.0010	+0.0003 −0.0005
115 and up	115 and up	115 and up	0.0002	0.0007	+0.0000 −0.0010	+0.0003 −0.0005

Machinery

The proper fit, therefore, for an inner ball bearing ring on a shaft is what is commonly called a light drive fit. Slight tapping of the inner ring should be sufficient to make it slide along the shaft onto its seat and against the shoulder of the shaft. The practice of locking the ring against this shoulder by means of a nut or its equivalent (except in the case of taper-bore bearings) is recommended under all circumstances.

Limits of Bearing Variations and Allowances for Shafts

The standard accuracy applied to the manufacture of ball bearings is for obvious reasons extraordinarily high. For the limits of variations for various sizes of bearings a standard maximum and minimum has been adopted by all ball bearing manufacturers. These variations have been regulated with a view to insuring proper fits on shafts turned within such limits as will permit of this operation being done commercially by the users of ball bearings.

The accompanying table gives limits of variations in the bores of ball bearings and the appropriate limits on the shafts to secure desirable fits. This table will be useful to the engineer or superintendent in specifying the plus and minus allowances on the working drawings.

For the benefit of those who have had little experience with ball bearings, it may be said that they are made to metric dimensions, the bores increasing by five millimeters, or 0.1969 inch—less than 13/64 inch. For each size of bore three different series of bearings are made, namely, light, medium, and heavy series. For the medium series larger balls are used than for the light series. Hence, the medium series bearing of the same bore as that of the corresponding light series will have a larger outside diameter and thickness. The same condition exists for the heavy series with reference to the corresponding size of the medium and light series, respectively. The purpose of this is obvious. It permits of a more economical selection of the proper bearing for a given shaft to support light, medium or heavy loads, as the case may be. Different manufacturers number their bearing sizes differently, and in most cases so as to identify the type of bearing, namely, whether it is a plain radial single-row bearing, a double-row bearing or a combination radial and thrust bearing. Since in all cases, however, the bores increase by five millimeters it will serve our purpose if we list the bearings in the accompanying table merely by their bores, and not by numbers and types.

Methods of Securing Inner Ring on Straight Shaft

Shoulder on Shaft.—Leaving a shoulder on the shaft against which one face of the inner ring may be clamped by a nut is the most satisfactory and economical method of mounting a straight-bore ball bearing on a straight shaft. In the majority of cases the design can be made so as to permit this method. Figs. 1 to 5 show simple and effective means of locking the nut.

No Shoulder on Shaft.—If the shaft cannot be designed so as to leave a shoulder on it, a spacer sleeve *A*, Fig. 6, between the inner ring of the bearing and some other rotating and laterally fixed member on the shaft will serve the purpose. The hub of a gear, worm, pulley, sprocket, or drum may be conveniently utilized. If nothing of the sort is available, Figs. 7 and 8 show a satisfactory solution of the problem. Fig. 7 shows the mounting of a bearing having a bore the same as or larger than the diameter of the shaft, and it is assumed that the size of the bearing cannot be reduced. By cutting down the shaft and driving on a bushing with a shoulder on one end, the bearing will be satisfactorily mounted, provided the bushing has a firm seat on the shaft and its outside runs true with the shaft. When a bearing must be mounted under such conditions away from the ends of the shaft, a good method is to use a bushing *B*, as shown in Fig. 8, which is held in position laterally by the split bushing *C*. The split bushing also serves the purpose of locking the inner ring between two shoulders. The same conditions for true running of bushing *C* with the shaft must obtain as in the case illustrated in Fig. 7.

The form of bearing mounting for vertical shafts shown in Fig. 13 will often be found very satisfactory. The illustration shows the mounting of the inner ring of both the

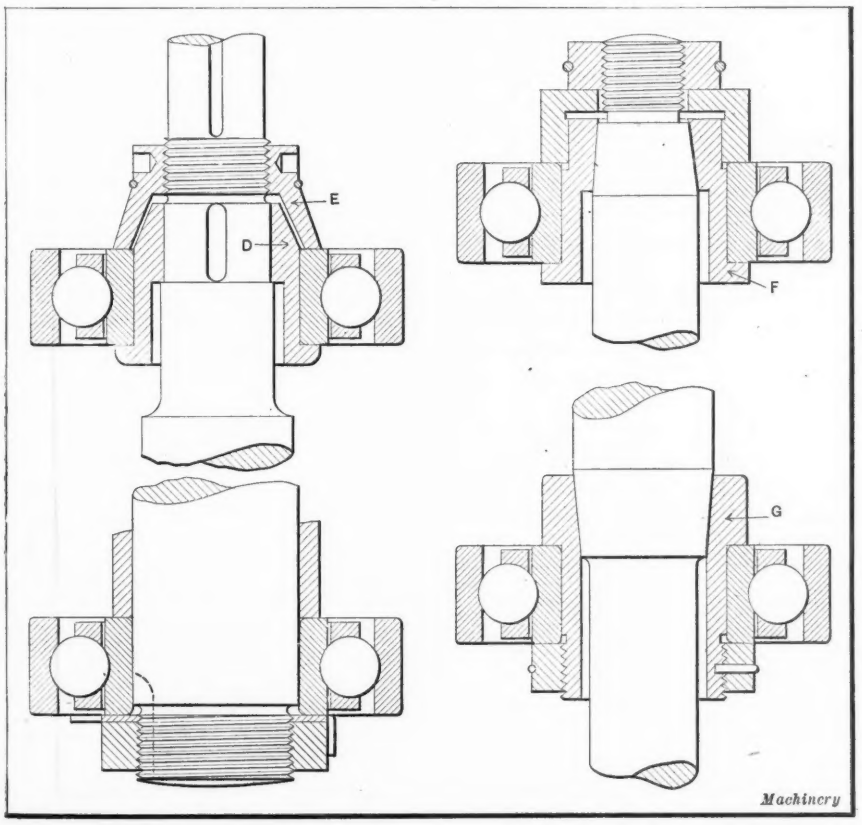


Fig. 13. Satisfactory Method of mounting Bearings on Vertical Shaft

Fig. 14. Method of mounting Bearings on Tapered Vertical Shaft

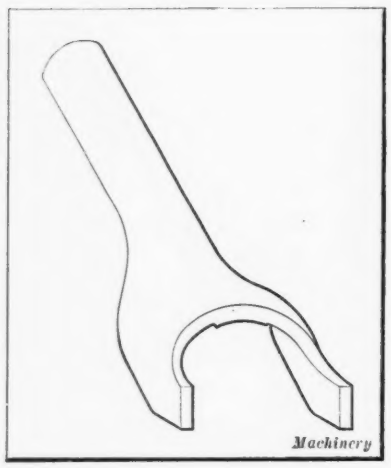


Fig. 15. Tool for removing Ball Bearings from Shafts

upper and lower bearings on the same shaft. The member *D* supporting the upper bearing is held against the shoulder on the shaft by means of the collar *E*, which, at the same time, serves to clamp the inner ring between shoulders. The inner ring of the lower bearing is locked in any of the ways previously given.

Adapters for Taper-bore Bearings. — Shafts that must remain perfectly cylindrical, particularly lineshafts and countershafts, permit but one method of mounting a ball bearing, namely, by the use of a so-called adapter, Fig. 9. This is a split bushing which can be clamped tight onto the shaft by driving over its tapered periphery a bearing with a taper bore. The bearing is held in position by a nut on the adapter. A 4-degree included angle is the accepted standard for taper-bore bearings.

Methods of Securing Inner Ring on Tapered Shaft

The mounting of bearings on a tapered shaft, as shown in Fig. 10, should be avoided as much as possible. There is great danger of stretching and cracking the inner ring, unless more judgment is used than the average working man possesses. A decidedly preferable method is shown in Fig. 11, which illustrates an adapter with a taper bore and straight outside, enabling the use of a straight-bore bearing. Since it is difficult to locate either the bearing or the adapter accurately, recourse may have to be had to the method shown in Fig. 12, if this accurate sidewise location is really essential.

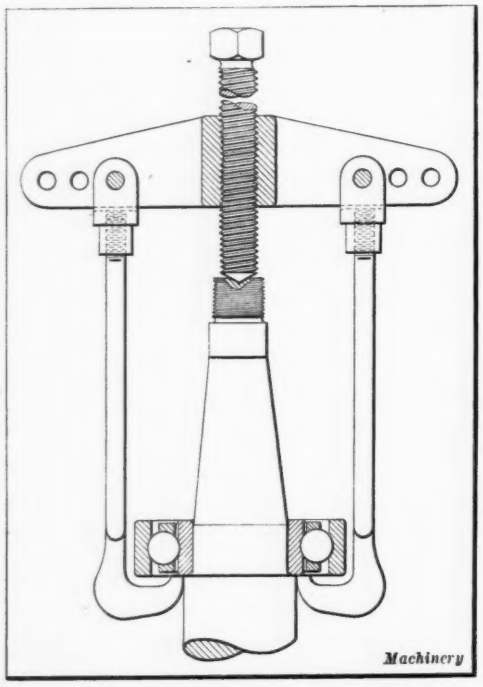


Fig. 16. "Bearing Puller" for removing Ball Bearings from Shaft

Fig. 14 illustrates the mounting of bearings on a tapered vertical shaft. The upper bearing is carried on a member *F* having a straight seat for a straight-bore inner ring which is clamped between shoulders by means of the nut on the end of the shaft. This nut, at the same time, drives the member *F* up on the taper of the shaft. For the lower bearing the weight of the shaft and the parts mounted on it is depended upon to establish a firm seat between the shaft and the member *G* on which is mounted a straight-bore bearing in any of the ways previously given.

In all cases the shoulder against which the bearing rests with one face of its inner ring should be at least ⅛ inch smaller in diameter than the outside diameter of the inner ring of the bearing. This is for the purpose of leaving enough of the inner ring exposed to pull off the bearing if necessary. Where the exigencies of the case may make it desirable, two notches diametrically opposite may be cut into the shoulder to enable a special tool called a "bearing puller" to be used, as illustrated in Figs. 16 and 18.

Machining Shaft for Mounting Ball Bearings

The seat of a ball bearing on a shaft should best be ground. When the finishing operation must be done in a lathe great care should be taken to make the seat very smooth. It is important that the seat be perfectly round. If it is not on a true circle the inner ring of the bearing will contact with the shaft only on high spots and soon will peen down, causing a looseness and often ultimate destruction of the shaft or bearing, or both. Working drawings should give plus and minus limits according to the table given in the foregoing, and they must be strictly adhered to. The operators and inspectors should be furnished with "Go" and "Not Go" gages. Micrometer reading should be discouraged. The fillets on the shafts should not exceed the blueprint dimensions. The latter, of course, must be slightly smaller than the chamfers of the bearings for which every bearing manufacturer furnishes specifications in his catalogue. If the fillet on the shaft were larger than the chamfer of the bearing, the bearing would contact only on the fillet instead of with the shoulder on the shaft. If side thrust were transmitted onto a bearing so mounted, the small area of contact between fillet and chamfer would soon wear, causing lateral play of the bearing in its seat with all the consequent destructive results.

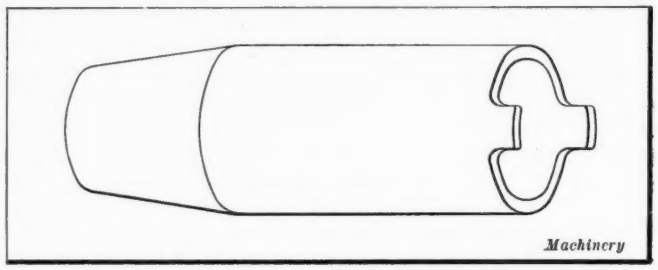


Fig. 17. Tool for removing Bearing mounted on End of Shaft

Driving Bearings on Their Seat on Shaft

Under all circumstances the force required to drive the bearing on its seat, should be exerted against the inner ring and not against the outer ring. This rule should be thoroughly understood and strictly enforced. A little oil should always be put on the seat before driving on the bearing. The driving should not be done by hammering directly against the inner ring. This is very hard, and such hammering is likely to chip or crack the ring or to damage the separator in the bearing. A tool like that illustrated in Fig. 15 should be used, which of course must not be hardened. If the bearing is mounted on the end of the shaft, the tool shown in Fig. 17 will serve well. In any event, the ring should be driven simultaneously at two diametrically opposed points of its outside surface. Tap gently, and

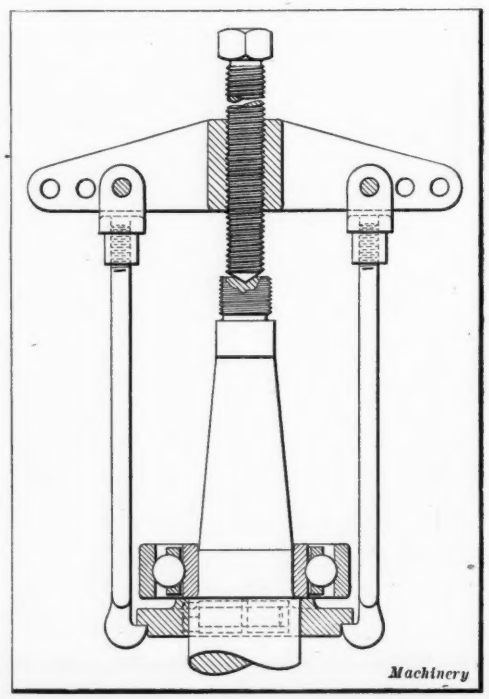


Fig. 18. Another Form of "Bearing Puller"

only with soft metals. If the bearing drives on too hard, take it off and use another one, or have the shaft ground or turned down. Never attempt to grind out the bore of the bearing to make it fit.

When mounting taper-bore bearings on adapters, Fig. 9, the same method of tapping the inner ring on its seat should be used as in the case of straight-bore bearings. The adapter, of course, should be backed up on its other end. It will not do to draw the bearing up on its seat by turning the nut. The adapters are made as thin as is consistently possible to keep down the size of the bearing. The threads on the adapter are consequently fine and only expected to hold the bearing in its place, and not to withstand the strain of driving it on its seat.

Pulling Bearings off Their Seats

The same fundamental rule applies in the case of pulling bearings off their seats as in driving bearings on their seats, namely: Don't exert force against the outer ring. Wherever possible the tool shown in Fig. 15 should be used and the bearing pushed off its seat. If the rules suggested in the foregoing for rust prevention have been followed and if the shaft was oiled before the bearing was driven on, it will come off very easily. If the bearing rests against the hub of a gear, etc., the bearing may best be driven off through the latter. There is no objection to driving the shaft out of the bearing, where this is more convenient, as long as the outer ring of the bearing is not used for support. Where the conditions require a tool of the type shown in Figs. 16 and 18, this must be used for pulling the inner ring off its seat. If notches are provided on the shoulder such a tool will work very well.

* * *

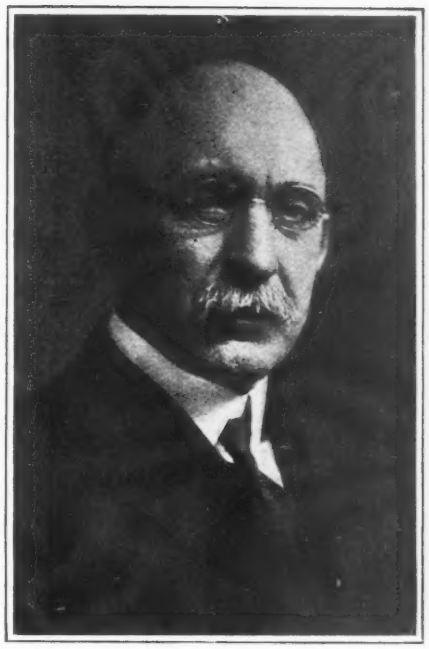
DR. IRA N. HOLLIS

Dr. Ira N. Hollis, the newly elected president of the American Society of Mechanical Engineers and president of the Worcester Polytechnic Institute, was born in Mooresville, Md., in 1856. He graduated from the Louisville, Ky., high school in 1872, and went as an apprentice in a machine shop for building and repairing all kinds of engines, principally those used on the Ohio River steamboats. His health failing, he changed his occupation, and finally entered the Naval Academy at Annapolis in 1874, from which he graduated in 1878. Two years later he was commissioned assistant engineer in the United States Navy, and in 1888 passed assistant engineer. He resigned from the Navy in 1893 to become professor of engineering at Harvard University, and in 1913 was called to his present position.

During the fifteen years after graduation from the Naval Academy he had a varied experience and was chief engineer of two ships. In 1884 he served with the advisory board that built the four ships of the White Squadron and spent some months in the inspection of machinery at Chester, Pa., New York City, and Nashua, N. H. He spent three years at the Union Iron Works in the inspection of machinery for the *Charleston* and on the naval board for fitting up the merchant ships as auxiliaries. In 1892 he was ordered to the Bureau of Steam Engineering under George W. Melville, then engineering chief, and his first service was a series of lectures at the War College on the new ships of the navy. His last work in the navy was drawing specifications for the machinery of the gunboat *Nashville* and designing machinery for new torpedo boats.

Dr. Hollis was twenty years with the Harvard University during the rejuvenation of its engineering work. He was active in the development of the university's facilities for sports, including a boat house, ball cage and stadium. The stadium was his idea and the use of concrete for its construction was novel. The stadium was the first of its type in the country, and it was probably the first large structure above ground, inasmuch as up to that time concrete had been used for only underground structures. He planned and built Pierce Hall, which was used for engineering for many years.

Dr. Hollis received the honorary degree of Master of Arts from Harvard University in 1899, the degree of L.H.D. from Union College in the same year, and the degree of Doctor of Science from the University of Pittsburg in 1912. He was elected to membership in the A. S. M. E. in 1884 and was its vice-president from 1911 to 1913. He is a member of the Society of United States Naval Engineers, the American Society of American Architects and American Engineers, the Boston Society of Civil Engineers and the Society for the Promotion of Engineering Education. He is the author of the History of the Frigate *Constitution* and War College Lectures on Naval Ships. He presented a paper before the A. S. M. E. in 1909, "Cast-iron Fittings for Superheated Steam," and has presented other papers dealing with naval, educational and engineering subjects.



Dr. Ira N. Hollis

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ANNUAL MEETING OF A. S. M. E.

The thirty-seventh annual meeting of the American Society of Mechanical Engineers was held in New York City December 5 to 8, inclusive. The program followed the usual lines, the president's reception being held on Tuesday evening, following the president's address. President D. S. Jacobus delivered an address on "Education in Engineering". The officers chosen at the annual election are as follows: Ira N. Hollis, president; Charles H. Benjamin, Arthur M. Greene, Jr., and Charles T. Plunkett, vice-presidents; Robert H. Fernald, William B. Gregory, C. R. Weymouth, managers; and William H. Wiley, treasurer.

On Wednesday the following papers were presented:

"The Proportioning of Surface Condensers," by George A. Orrok.

"The Testing of House Heating Boilers," by L. P. Breckenridge and D. B. Prentice.

"Water for Steam Boilers—Its Significance and Treatment," by Arthur C. Scott and J. R. Bailey.

"Proposed Code of Safety Standards for Cranes."

"Steam Safety Valves," by George H. Clark.

"Efficiency of Propulsive Machinery and Late Developments in Naval Engineering," by H. C. Dinger.

"Standardization of Power Plant Operating Costs," by Walter N. Polakov.

"Report of Efficiency Tests of a 30,000-kilowatt Cross-compound Steam Turbine," by H. G. Stott and W. S. Finlay, Jr.

"The Design and Test of a Large Reclamation Pumping Plant," by G. C. Noble.

Following the presentation of these papers, memorial exercises were held in the auditorium for John E. Sweet, past-president, honorary member and founder of the society. After these exercises in the afternoon there was a conference of the local sections. The following papers were presented:

"The Utilization of Waste Heat for Steam-generating Purposes," by Arthur D. Pratt.

"Graphic Methods of Analysis in the Design and Operation of Steam Power Plants," by R. J. S. Pigott.

"Power-plant Efficiency," by Victor J. Azbe.

"The Impact Tube," by Sanford A. Moss.

"The Flow of Air and Steam through Orifices," by Herbert B. Reynolds.

"Topical Discussion on Industrial Management."

"Heat Transmission through Various Types of Sash," by Arthur N. Sheldon.

"Spontaneous Ignition Studied by Means of Photographic Plates," by Frederick J. Hoxie.

Vibration in Textile Mill Buildings," by G. H. Perkins.

"Standardization of Machine Tools," by Carl G. Barth.

"A Proposed Plan for the Activities of the Machine Shop Practice Sub-committee of the A. S. M. E.," by H. K. Hathaway.

The capacity of the rooms on the fifth floor of the Engineering Societies Bldg. was taxed Wednesday evening by those attending the smoker and vaudeville entertainment. Frank B. Gilbreth, the well-known efficiency expert, gave an illustrated talk on his experiences traveling to Europe, following which was a varied entertainment provided by hired talent.

The papers presented on Thursday included the following:

"Accurate Appraisals by Short Methods," by J. G. Morse.

"How Does Industrial Valuation Differ from Public Utility Valuation?" by John H. Gray.

"Relation between Perpetual-inventory Value and Appraisal Value," by Charles Piez.

"Valuation of Industrial Properties vs. Valuation of Industrial Methods," by Walter N. Polakov.

"Productive Capacity a Measure of Value of an Industrial Property," by H. L. Gantt.

Five papers were presented at the gas power session held under the auspices of the sub-committee on gas power as follows:

"A Gas Producer for Bituminous Fuel," by O. C. Berry.

"The Commercial Sampling and Analysis of Producer Gas," by P. W. Swain.

"The Ratio of the Specific Heats and the Coefficient of Viscosity of Natural Gas from Typical Fields," by Robert F. Earhart.

"An Investigation of the Internal-combustion Engine as Applied to Traction Engines," by A. A. Potter and W. A. Buck.

"Illustrated Review of the Development of the Werkspoor Marine Diesel Engine," by Thomas O. Lisle.

The evening was devoted to a symposium on aviation in the auditorium, and the annual reunion. Illustrated addresses included moving pictures of recent flights of the original Langley machine.

On Friday simultaneous sessions were held at which the following papers were presented:

"Illustrated Review of the Development of Our Fleet and Naval Stations," by W. L. Cathcart.

"Heat-treatment of Wrought-iron Chain Cable," by F. G. Coburn, W. W. Webster and E. L. Patch.

"An Analysis of Marine Safety Valves, with Suggestions for Repairs and Improvements," by E. F. Maas.

"The Talbot Boiler," by Paul A. Talbot.

"The Downflow Type of Steam Boiler," by John C. Parker.

"Clasp Brakes for Heavy-passenger-equipment Cars," by T. L. Burton.

"Mechanical Design of Electric Locomotives," by A. F. Batchelder.

"Pulverized Fuel for Locomotives," by J. E. Muhlfeld.

Public hearings by the boiler code committee were held on Friday and Saturday.

As usual, excursions were made to nearby points of interest among which were the new Telephone Bldg., new Equitable Bldg., works of the Otis Elevator Co. in Yonkers, New York Steam Co.'s plant, and the Navy Yard in Brooklyn.

* * *

WARTIME WAGES

A young man from an Ohio farm got work in a munitions factory and made $6 a day. Suddenly the factory reduced its force and he returned home with a lot of fancy clothes and a new outfit of expensive tastes. The money had come easily and had gone quickly. His case is typical of many thousands within the past year. One munitions plant laid off more than two thousand men in a week. A hundred miles away a plant that had been paying big wages and large bonuses closed and turned out its men without warning. Most of them had been spending as they went along. Their big pay had done them little good. In leading them to extravagance it was an evil. We all know that the labor situation has been critical. The sudden rise in wages demoralized the supply. Farms were especially hard hit. Their labor was the kind the factories wanted, and the factories bid the limit and threw ethics out of the window. They raided conservative concerns and cared not how the men came, so long as they got them. In its effect upon employment the war has been a curse, because it has encouraged bad practices. When the young man on the Ohio farm looks at his fancy clothes and thinks about what became of his money he may get a useful angle on the wage question. We hope so, and we hope others will think of it from the same angle. But to be honest, we doubt that it will do much good—more's the pity.—*Country Gentleman.*

OCCUPATIONAL DISEASES

BY CHESLA C. SHERLOCK [1]

Under the workmen's compensation acts there is no recovery from an employer for occupational or industrial diseases. When the courts were first presented with this question, they found that the only recovery provided for, under those statutes, was for accidental injury or for injury arising in the course of employment by accidental means. It will be seen, then, that the only theory on which recovery for such a disease could be supported would be on the theory that such an infirmity was the result of an accident.

The courts of this country have followed the lead of the English courts and are practically united on the proposition that there is no recovery for a purely occupational or industrial disease. However, they have quite uniformly held that where the disease sued upon results from a *bona fide* injury there will be recovery against the employer. Indeed, most of our compensation acts expressly provide that there can be no recovery in such cases; and those that make no mention of the subject have been construed to bar a recovery.

Certain occupations, if followed for any length of time, are exceedingly dangerous to the health of the employe. This is quite generally known to the employe as well as to the employer. If the employe, having the right to choose his own work, engages in a dangerous occupation and in due course of time contracts an occupational disease, there should be no recovery under the compensation acts. The purpose of those statutes was not to act as insurance for the employe against the reasonable risks of his employment, but rather to safeguard his interests in case of sudden injury or loss of his faculties so as to impair his earning capacity.

The courts have handed down some specific decisions that will tend to illustrate the line of reasoning followed. For instance, they have said that a skin disease caused by the workman's hand coming in direct contact with poisonous substances, in the course of his employment, is not an accident. Likewise, they have held rash, dermatitis and eczema are not accidents. Ptomaine poisoning, typhoid fever, enteritis, lead poisoning, and copper poisoning have all been held not to be accidents. However, in Massachusetts, lead poisoning was held to be a recoverable injury, as the statute in that state provided for recovery on personal injury, and the court said that lead poisoning was within the technical meaning of the law in that state. Likewise, a recovery was allowed in the same state for blindness caused by optic neuritis, produced by poisonous gases.

Where the disease is the result of some unusual condition of work, as where a workman, unduly exposed to the elements, contracts a severe cold which runs into pneumonia and death results, recovery will generally be allowed. Following this line of reasoning, the New York courts have said that where a person was employed to cut weeds along a railroad right-of-way and died as a result of infection from poison ivy, the disease was accidental and recovery was allowed. Sunstroke and heat prostration have both been held accidental, but this question is largely one of fact and depends upon the circumstances of each case. Recovery has been allowed for blood poisoning when it was clearly demonstrated that it was contracted in the course of the employment. And the courts have gone so far as to say that the mere fact that an employe is suffering from disease at the time of the injury complained of does not bar a recovery. It may be shown that, although the workman was in a diseased condition at the time of the injury, such injury aggravated the disease to the extent that death resulted and recovery will be allowed.

In regard to general breakdowns and nervous disorders due to overwork, the courts seem to be of the opinion that they correspond too closely to occupational diseases for recovery to be allowed on them. Such disorders are not accidents within the meaning of the compensation acts. It will be seen that diseases are divided into two classes by the courts: occupational or industrial, for which there is no recovery; and those resulting from injury or aggravated by injury sustained in the course of employment, for which recovery is allowed.

[1] Address: 408 S. & L. Bldg., Des Moines, Iowa.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

MICROMETER MEASUREMENTS

The article in the October number of MACHINERY, showing a large snap gage with micrometer adjustment and giving tables of figures in ten-thousandths of an inch for running, driving and shrinking fits, makes me think of an experience I had when a kid in a machine shop in the early 70's, where the "instruments of precision" were a pair of long-legged calipers and a two-foot rule graduated to 16ths. A near-by rolling mill was frequently breaking their squeezer pinion, and it was a part of our job to have on hand a duplicate ready for immediate use. This pinion was a cast-iron bevel gear about 24 inches in diameter with a 9-inch hole, which had to be a good driving fit. I used to face up the gear hubs and rough-bore them, but a down-east machinist called "Williams" —a thin, medium-sized man with red whiskers—was always sent over to the lathe to take the finishing cut. One day, after he had set the tool and had it cutting to his satisfaction, he was asked: "What rule have you for setting your calipers for the allowance for the different kinds of fits—such as running, driving and shrinking?" He didn't reply for a moment, but stood there running his fingers through his long red whiskers; then he said: "Cox, I ain't got no rule; I jist guess at it—but I'm a d—— good guesser."

Cleveland, Ohio. J. D. Cox

BABBITTED MACHINERY CONSTRUCTION

The article entitled "Babbitted Machinery Construction" that appeared in the November number of MACHINERY is both interesting and timely, and graphically illustrates a common mistake made by many engineers and designers, either through prejudice or a desire to follow the trend of the times. That a good babbitted bearing is to be preferred to a poor bronze one goes without saying. The experience of many years has proved that a babbitted bearing, properly lubricated, gives a low coefficient of friction and long life as well.

It is common practice to babbitt the main bearings of marine engines, and this material gives entire satisfaction, notwithstanding the enormous weight of the crankshaft and other parts, connecting-rods, crossheads, pistons and piston-rods, to say nothing of the extra weight brought to bear by the steam pressure. Yet a marine engine must run continuously from the time the ship leaves the port until she docks again, for it is exceedingly dangerous to stop a ship for repairs when there is a heavy sea running. Marine-engine main bearings that are babbitted often run for many years without attention, aside from a little scraping and adjustment of liners, and when they are worn to a point that demands renewal, they are replaced at a comparatively trifling cost.

In the past, many machine-tool builders employed babbitted bearings in lathes, screw machines, small milling machines, etc., with very satisfactory results. In such cases, the babbitt is poured over a mandrel somewhat smaller than the desired finished size and later is thoroughly peened. The bearings are then bored and line-reamed. This method gives excellent results, as any mechanic of the older school can testify. Yet the purchaser of machinery at the present day looks askance at a good, honest babbitted bearing, thinking that it is a sure sign of cheap construction. One concern that obtained excellent results with babbitted bearings made semi-automatic machines for folding collar blanks, preparatory to stitching, that had several shafts connected by gearing. These shafts were carefully lined up by means of templets and then babbitt was poured in the journals. As the spacing of the shafts had to be fairly close, because the gears had to mesh properly, considerable money was saved by this method; for otherwise it would have been necessary to bore the frames very carefully, or make expensive jigs.

The babbitted bearing has earned for itself an established place in the mechanical world, and engineers, designers and those who contemplate the purchase of machinery should investigate its merits before hastily condemning it as little better than a makeshift, or, at best, a short-cut toward a desired end.

Indianapolis, Ind. F. B. JACOBS

DEVICES FOR TWISTING AND BENDING ECCENTRIC RODS, LINK HANGERS, ETC.

Fig. 1 shows an excellent device for twisting eccentric rods, link hangers, and parts of a similar nature. In repair work, when links and their parts are being assembled on an engine, the jaws of the eccentric rod in nearly all cases are out of alignment with the link; as a result, the rod must be twisted a little to make the parts fit as they should. The illustration shows plainly how the device is used. The hooked ends of the

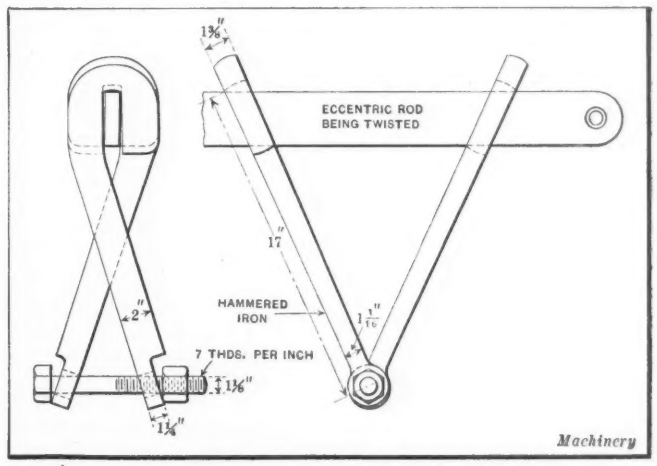


Fig. 1. Device for twisting Eccentric Rods, Link Hangers, etc.

straps are put on the eccentric rods, from 12 to 18 or 20 inches apart and then the other ends are brought together by screwing up the bolt.

In Fig. 2 is shown a handy and, in most shops, a badly needed device for bending eccentric rods and link hangers or similar objects. After part *A* is put on an eccentric rod *B* the key *C* is driven in. Tightening the set-screw *D* will bend the rod. Sometimes it is necessary to make two bends because the rod *B* and the link *E* are so far out of alignment. To bend the rod at *F*, would throw it over nearly in line but would twist it so much that the pin would not go in even if the jaw would go over the link. So it is necessary to give it a big bend at *F* and a reverse bend at *G* to get the parts properly aligned. M. K.

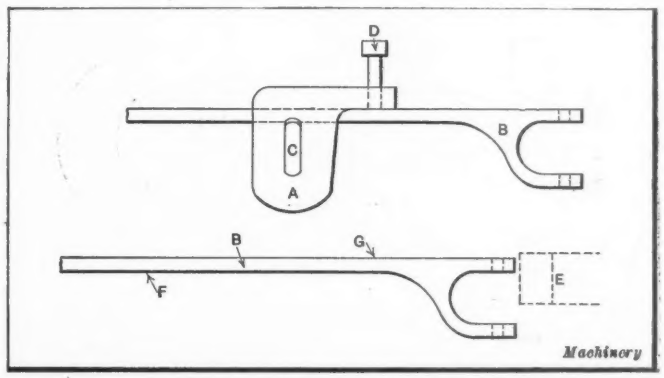


Fig. 2. Device for bending Eccentric Rods and Link Hangers

THAT T-SQUARE PROTRACTOR

The "Handy T-square Protractor" shown on page 246 of the November number of MACHINERY has at least one disadvantage—that of rapidly becoming inaccurate. The least wear or batter of the corner *A* of the head will throw it badly out of true. This error will be multiplied many time at the blade, and the shorter the head the greater will be the error thus caused. Further, when one has to work on a small sheet, it is not usual to employ a long-bladed square; and the system there shown would require graduating both a long- and a short-bladed square, if not the squares used. The writer uses glass-bladed squares; and graduating their blades with a diamond or wax and acid will not lessen the liability of the blade's breaking near the head.

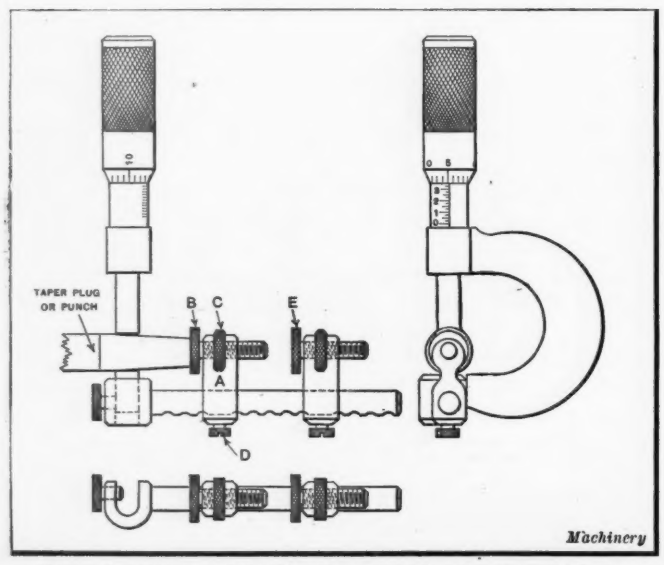
Another way of being sure to get tapers right is to graduate the end cleats of the drawing board with a knife point or other scribing device. When a short-bladed square is used, one that does not reach to the right-hand cleat, this way is as accurate as the one previously described; and where the blade reaches to or beyond the right-hand end of the board, it is even more accurate. When the blade is set to the required taper, a light line is drawn across the paper and the tapered lines on the drawing are made parallel to this by the usual method with triangle and square. (The average double-slotted parallel rule, being an invention of the devil and inaccurate, is barred from draftsmen's work, and the roller type is inapplicable to vertical boards.) If the drawing is small in proportion to the board, no setting line in the paper is necessary, as the guide lines on the board suffice. Where the T-square has a swivel head, the graduated board is as handy as the proverbial pocket in a shirt.

New York City. ROBERT GRIMSHAW

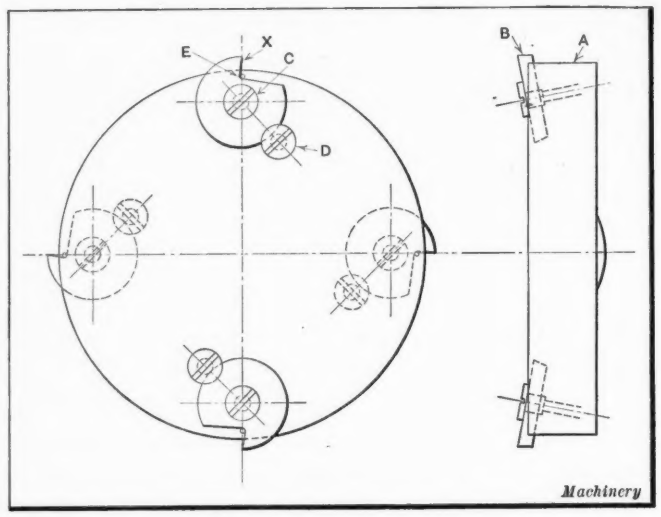
MICROMETER TAPER CALIPER ATTACHMENT

Where taper plug gages, punches, arbors, etc., are made in quantity, the attachment shown in the accompanying illustration will be found very convenient for calipering, and will give accurate results. Its construction and the manner of attaching it to the micrometer are clearly shown. The standards *A* are placed in approximately the correct position, and the stop *B* can then be set in the exact position after the clamp ring *C* is loosened. Should it be desired to caliper a second taper, the screw *D* at the bottom of standard *A* may be loosened so that the standard will fall into an inverted position. Then the second stop *E* may be used. If it is desired to again caliper the first taper, standard *A* may be placed in its former position and screw *D* again tightened in the former position. Should the work have a tip at the end that is to be removed after grinding, a screw with a hole in it is used in the standards instead of stops *B* and *E*.

Bridgeport, Conn. L. E. HARRISON



Micrometer Attachment for calipering Taper Plug Gages, Punches, etc.



Side Milling Cutter of Cheap Design

SIDE MILLING CUTTER

The side milling cutter shown in the accompanying illustration is one of those odd arrangements that are recommended chiefly because of cheapness but cannot be used as manufacturing tools. It consists of a body *A*, cutting disk *B*, stud *C* that holds the cutting disk in place, and a screw *D* that locks the cutting disk in place when edge *X* is against pin *E*. The body is made of machine steel. The cutting disks are easily ground and may be replaced readily when worn out, or thicker cutting disks may be used for milling wider grooves, resulting in a saving where the first cost of the tool is limited. In the cutter shown, two cutting disks are placed on each side of the body. This cutter was the middle one of a gang of three, the end cutters having cutting disks only on one side. F. SERVER

COLD-ROLLED STEEL

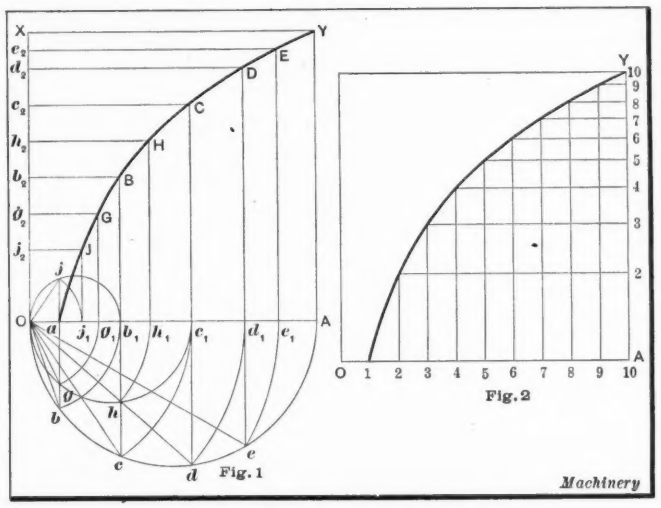
Machinists commonly call all bright steel "cold-rolled," whether rounds, squares, flats, or shapes, but this is not a correct designation. Shafting, rounds, key-stock, etc., are given their finish and accuracy by cold-drawing, which is quite different from rolling. The quality of the steel also differs; broadly speaking, cold-rolled steel is soft and easily bent or punched, while that which is cold-drawn is harder and stiffer. Cold-rolled steel is obtainable only in flats, so there is not much danger of getting the two kinds mixed in everyday practice; it is well, however, to remember that there is a distinction, and there are cases where the failure to order correctly has been costly. D. A. H.

"Cold-rolled" is, in general, a misnomer, but the foregoing statement is not altogether correct. The Jones & Laughlin Steel Co. of Pittsburg, is still making round shafting by the cold-rolling process.—EDITOR.

CONSTRUCTION FOR LOGARITHMIC GRADUATION

The following construction, which deserves to be more widely known among draftsmen and students of graphics, may be used for dividing a line for logarithmic graduation, when the line is of an odd length.

Draw a square *AOXY*, Fig. 1, on the line *AY*, which it is desired to divide logarithmically, and take on *OA* a point *a*, such that $Oa = 1/10OA$. On *OA* draw a semicircle and draw *ab* at right angles to *OA*, cutting the semicircle at *b*; then with *O* as a center inscribe the arc bb_1, making $Ob_1 = Ob$, and draw a vertical line through b_1 (assuming that *OA* is horizontal) to meet in *B* a horizontal line through b_2, which is such that $Ob_2 = 1/20X$. Draw b_1c vertically to meet the semicircle in *c*, and inscribe arc cc_1 from *O* as a center; bisect b_2X in c_2 and draw horizontal and vertical lines through c_2 and c_1 to meet in *C*. The point *D* is next found by finding d_1 similarly, and bisecting c_2X in d_2 and projecting horizontal and



Construction for Logarithmic Graduation

vertical lines as shown. We thus get points *BCDE* upon a curve; to obtain intermediate points, draw a semicircle on Oc_1, and draw the arcs gg_1 and hh_1 from the center *O*. We then bisect Oc_2 in g_2 and draw horizontal and vertical lines through g_2 and g_1, respectively, to meet in *G;* and repeat the construction for *H* by bisecting b_2c_2 in h_2. The point *J* is obtained by drawing a semicircle upon Ob_1. In this way any desired number of points may be obtained, the resulting curve being a curve of logarithms. To save confusion with the construction lines, this curve is redrawn in Fig. 2, and the manner in which it is employed to divide *AY* into logarithmic graduations is shown. The base *OA* is divided into ten equal parts, and the resulting points are projected vertically to the curve, the points of intersection being then transferred to the vertical line *AY* by horizontal projections as shown. E. S. A.

MECHANICS' SOAP PASTE

The demand for soap or hand paste, or sand soap as it is more generally called, has increased to such an extent in the last few years that many companies have been organized for the purpose of manufacturing it. Each department store, drug store and corner grocery store has on its shelves a dozen different brands, together with the usual "superior article made by itself." Also, the spare time of many mechanics is spent in boiling fats and filling cans for their local clientele. About two hundred trade-marks are registered, by Massachusetts men, with the Secretary of State in Boston. The number registered in Washington from all the states must be enormous.

Inasmuch as an increasing number of people are beginning to do the mechanical work on automobiles and motorcycles, the field for the paste is continually growing. But to add even one brand to the already long list would seem senseless from a financial point of view. Some manufacturers will furnish the paste in bulk or put it up under any trade name desired. Most of these pastes are sold for 10 cents a can, or 25 cents at retail, but there are many brands that retail for 5 cents a can. The profit to the retailer is so much greater in the case of the inferior pastes that good paste can be had only from the most reliable dealers.

A soap paste can be made at home at a trifle less than the cost of the best hand soap. But a paste as good as the best on the market cannot be made and sold at a profit, either wholesale or retail, without the use of expensive facilities for its manufacture. In addition, the cost of raw materials has of late increased from 100 to 300 per cent. The lithographed cans alone cost two cents each, in lots of 25,000, and hardly any firm today will consider a smaller order. Firms, like Colgates and Armours, that have an extensive business in this line have special departments for making the cans, as the difference of a mill in the cost of each can may mean a profit or a loss for their product.

The making of soap paste at home is not altogether a difficult process. The body of a good paste is composed mostly of fatty acids. In the best sand soaps talc is sometimes added, while the cheaper grades are often adulterated with gypsum, lime, pipe clay, or sodium silicate to make a larger quantity of soap out of the same amount of the more expensive body. In the poorer grades, an equal part of rosin is often boiled with the more costly tallow to lessen the cost of production. Tallow and rosin boiled together absorb a great amount of water, and the more water that a soap can contain the greater will be the profit. All these adulterants are of no use and simply act as fillers. In fact, if sodium silicate is introduced into the soap at any except the right stage, it will spoil the compound. The usual test for detecting the presence of adulterants in the ordinary soap is to dissolve some of it in distilled water or alcohol and then note if there is a precipitant. The detection of these adulterants is more difficult with sand soap, however, because of its more solid ingredients.

The process of separating the fatty acid and glycerine from the tallow or lard probably requires the only technical skill needed in this work. As there is an element of danger in this, especially when sulphuric acid is used as a decomposing agent, it might be well for a person desiring to make soap paste for his own use to purchase the fatty acids from the nearest rendering works. As a further guarantee of the purity of the acids he should add some antiseptic. Cuts and scratches have often been made worse by the introduction into the sensitive tissues of a piece of contaminated grit and the lack of a healing antiseptic. An antiseptic is found in all good pastes, seldom in the poor ones. It is usually present in the form of antiseptic cocoanut oil. The use of sassafras as a perfume had almost become extinct until it was revived by hand paste. Where, why, or when the odor of sassafras was declared to be the national perfume for these pastes I do not know; it seems to be generally adopted, however.

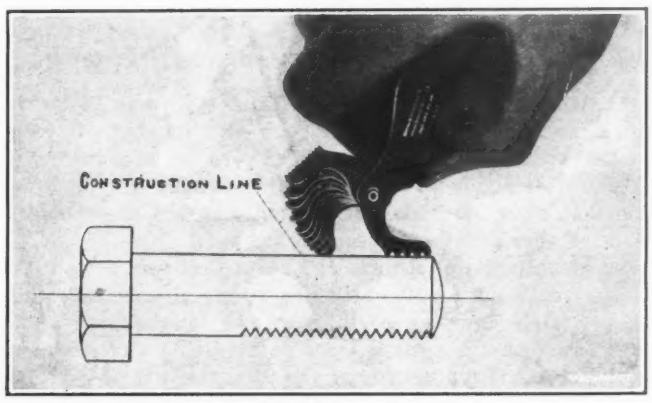
Finely ground pumice is a necessity in all good soap pastes; some of the best pastes are made up almost entirely of fine pumice stone and just enough pure neutral soap to make it lather well. These pastes remove the stains and leave the skin soft, white, and smooth. Coarse pumice stone will scratch the skin. Cheap soap pastes contain sea sand or glass sand, or both. Although glass sand is finer than sea sand, it scratches and irritates the skin more. There is not much choice, however, between the two, and any soap that contains either should be avoided. An excess of alkali in soap paste will cause the hand to chap, and is, therefore, avoided by the best manufacturers.

Worcester, Mass. ROBERT J. SPENCE

LAYING OUT SCREW THREADS

The draftsman and designer will find that screw threads can be more easily and quickly laid out by means of the screw pitch gage than by the old method of using a pair of dividers. The accompanying illustration shows the gage used for laying out a ⅞-inch cap-screw having nine threads to the inch. Two light construction lines are laid off for the outside diameter of the screw, then the gage marked nine threads to the inch is found and its teeth are pressed into the paper along the light construction lines. From the indentations thus formed, the threads can be easily and accurately laid out.

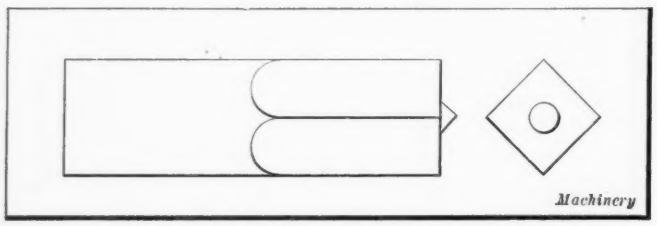
Prince Bay, N. Y. WARREN H. BARTON



Method of using Screw-pitch Gage

HEAVY-DUTY PUNCH

To make a heavy-duty punch that will stand up and hold a good cutting edge for from ten to twenty times as many pieces as the ordinary flat-pointed punch, turn up a 90-degree teat on the end, 3/32 to 1/8 inch long, according to the size of the punch. This teat will carry the stock ahead of the punch



Heavy-duty Punch with Central Teat to relieve Pressure on Cutting Edge

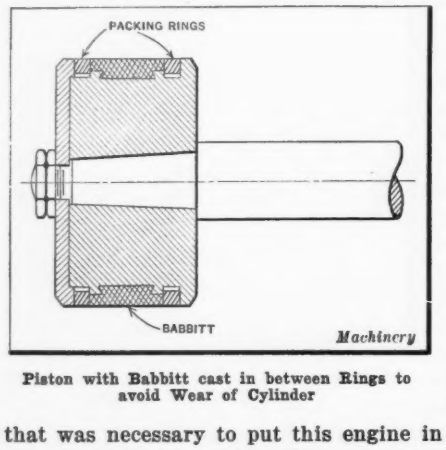
and relieve the pressure at the cutting edge. It gives a long life to the cutting edge of punches, especially those with sharp corners. A good lubricating compound is essential to assist in stripping the work from the punch.

Ypsilanti, Mich. A. E. SANFORD

The use of a central teat on boiler plate punches was long ago found to greatly improve their action and durability. The teat centers the punch on the plate directly over the die, and holds it steady and in line, thus preventing deflection, broken punches and chipped dies. Of course the same improvement may be realized with punches used for other metal punching when so made.—EDITOR.

BABBITTED PISTON CONSTRUCTION

We recently had occasion to overhaul our seventy-two-horsepower steam engine, and after the engineer had removed the cylinder head and piston I was surprised to find that calipering showed the cylinder to be only a scant 1/32 inch out of round. The engineer said that it had not been bored for six years, which seemed incredible until I examined the piston and found that the metal had been turned away between the rings to make a space in which had been cast a good grade of babbitt metal, which took all the wear between the piston and cylinder. During the course of my experience I have frequently seen locomotive cylinders worn as much as 1/16 inch out of round after being in service for about eighteen months, while our engine had been running continuously for six years without showing a serious amount of wear. All that was necessary to put this engine in good running order was to renew the piston rings, face the valve seat and true up the valve stem and piston-rod.



Piston with Babbitt cast in between Rings to avoid Wear of Cylinder

Toledo, Ohio. R. B. SPENCER

EXTRACTING ROOTS OF NUMBERS

In the October number of MACHINERY, there was an inquiry for a method of extracting the roots of a number. It seems to the writer that for all practical purposes any method of actually extracting these roots is too tedious and laborious, and that, as stated in MACHINERY not long ago, use should be made of what has already been worked out.

By using tables of squares and cubes that may be found in almost any handbook, the fifth root of any given number may be accurately found to several places by interpolation, as the fifth power of a number is equal to the product of its square by its cube. For instance, suppose that the fifth root of 7214 is required, accurately, to five places. A moment's inspection of the tables will show that the product of the square and the cube of 6, or $6^2 \times 6^3 = 7776$, is a little too large. Looking into the fifties and inserting the decimal point in the proper place to get the powers of 5.9, it will be found that the fifth power of 5.9, or $5.9^5 = 5.9^2 \times 5.9^3 = 7149.3$, is too small. But by interpolation $100 \times \frac{7214 - 7149.3}{7776 - 7149.3} = 10$; therefore, 5.910 is part of the root. In the same way, $5.91^5 = 5.91^2 \times 5.91^3 = 7210.03$, and $5.92^5 = 5.92^2 \times 5.92^3 = 7271.25$. Then by interpolation $100 \times \frac{7214 - 7210.03}{7271.25 - 7210.03} = 6$; therefore, 5.9106 is the required root.

A result closer than four or five places is seldom of special value, and the foregoing method is not very tedious. Fourth and sixth roots may also be found by means of the tables in two operations, interpolation usually being necessary.

However, by using a five-place table of logarithms, the same result may be obtained in a minute's time. To obtain greater accuracy a more extensive table should be used. In the present case, the number is between 1000 and 10,000; therefore, the integer of the logarithm is 3. From the table the decimal part of the logarithm of 7214 is 0.85818. The logarithm of the required root then is $3.85818 \div 5 = 0.77164$. From the table, the corresponding number is found to be 5.9106.

A. H. KIRKER
Homestead, Pa.

Convenient Arrangement of Feelers on Key Ring

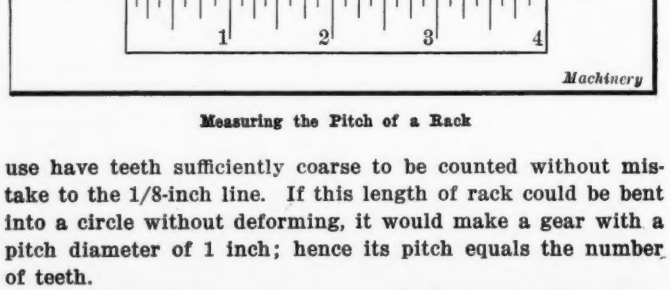
KEY RING FOR HOLDING FEELERS

The writer finds a key ring, of the type here shown, very useful when he has to use different sizes of feelers a great number of times. The feelers are removed from the regulation holder and slipped on the key ring by pushing back the knurled plunger that slides on the ring proper.

Bridgeport, Conn. JAMES MCINTYRE

TO FIND THE PITCH OF A RACK

When it is required to know the pitch of a rack, many mechanics resort to such roundabout ways as trying a cutter to fit the teeth, matching a gear and computing from that, trying to count the teeth in one inch and converting from circular to diametral pitch, etc. The simplest way is to read the pitch directly from a steel rule. The number of teeth in 3 1/8 inches is the diametral pitch of the rack. To be exact, it should be read to 3 9/64 inches, but the racks in common use have teeth sufficiently coarse to be counted without mistake to the 1/8-inch line. If this length of rack could be bent into a circle without deforming, it would make a gear with a pitch diameter of 1 inch; hence its pitch equals the number of teeth.

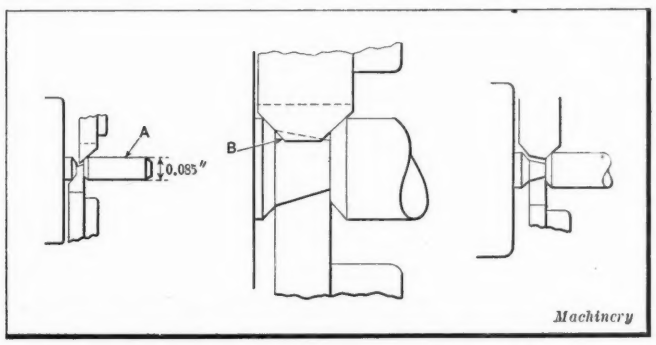


Measuring the Pitch of a Rack

Middletown, N. Y. DONALD A. HAMPSON

CHAMFERING PINS IN THE AUTOMATIC SCREW MACHINE

Pins and rivets similar to that shown at *A* are made in large quantities in the manufacture of typewriters, guns, etc. The end is chamfered to facilitate assembling and also to remove the burr thrown up by the cut-off tool when it first comes in contact with the stock. In the following the writer



Arrangements of Chamfering and Cutting-off Tools

describes an improved method of machining similar parts in the automatic screw machine. This method will greatly lessen the liability of pins under ⅛ inch diameter breaking off next to the chuck, a condition which quite often makes it necessary to cut down the feed and production.

In the left-hand view is shown a much used method of making pins. But this requires a number of cutting-off tools, to suit the various diameters of wire from which the pins are made. A more recent method is to use a standard cutting-off tool for all pins and the double chamfering tool shown in the center view. The fault of this method is that part *B* of the chamfering tool will come in contact with the conical shaped part of the pin formed by the cutting-off tool, and reduce it sufficiently to cause this part of the work to break off. In the case of pins 3/32 inch in diameter, or less, the large amount of cutting surface of the chamfering tool in contact with the wire will cause sufficient torsion and pressure to break off the wire close to the chuck. On small work, the cause is not apparent so that very often the feed of the cutters is reduced in an effort to overcome the difficulty; this, of course, means reduced production.

In the right-hand view is shown a solution of the difficulty without loss of production, providing the cams are made correctly. With this method the chamfering tool follows the cutting-off tool into the stock just far enough to chamfer the rear end of the work and then either dwells or withdraws until the pin has been cut off, when it again moves forward and chamfers the front end of the wire for the next pin. The order of operations for making the pin in a No. 00 Brown & Sharpe automatic screw machine is as follows:

Operation	Number of Revolutions of Stock	Hundredths
Feed stock to stop (lead and front cross-slide cam)	20	13
Cut off, 0.062 inch travel at 0.00045 inch feed (lead and front cross-slide cam)	37	85½
Chamfer, 0.022 inch travel at 0.0004 inch feed (rear cross-slide cam)	55	(34)
Chamfer tool clear stock (rear cross-slide cam)	40	(24½)
Chamfer end of bar, 0.025 inch travel at 0.0005 inch feed (rear cross-slide cam)	46	(29)
Clearance (lead and front cross-slide cam)	3	1½
Total	160	100

The fastest speed of the machine is used; this is 2400 revolutions per minute, or a surface speed of 54 feet per minute. The feed per revolution for the chamfering tool is less than that for the cut-off tool so that it will follow the latter into the stock. The net production resulting from the lay-out is 8100 a day, and the time for one piece, four seconds.

The adoption of this method of making pins allows the front end of the bar to be chamfered after the pin has been separated, thus eliminating the breaking of a large percentage of the work.

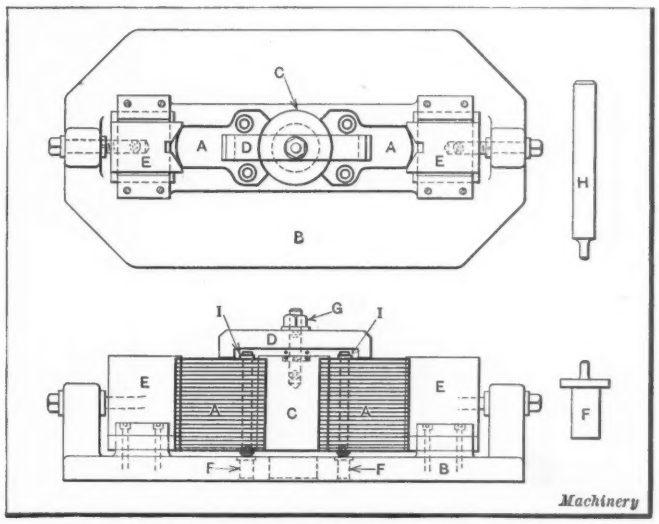
Philadelphia, Pa. HARRY BOYNE

THE "PUSHING STROKE"

I was taught at college, in connection with my drafting course, that one should never push on a drawing pen; that the drawing strokes should always be pulls. And later, when teaching mechanical drawing, I taught the same doctrine. After having had more practical experience, however, I have found that in some cases pushing strokes are better than pulling strokes. This is particularly true where a curve must be accurately traced. On a pushing stroke, it is always possible to see what is being done and the curve can be followed with surprising accuracy, no matter how irregular it may be. If attempted with a pulling stroke, the pen covers the line so that the work cannot be seen. Irregular curves usually follow most curves approximately, but not accurately. So, with the aid of an irregular curve and the pushing stroke, it is a simple matter to follow the curve to be inked with an accuracy that cannot be criticized. N. G. NEAR

FIXTURE FOR RIVETING THIN PLATES

While it is seldom necessary, in shop practice, to use a fixture for riveting, the arrangement shown in the accompanying illustration gave much better results than could have been obtained by the usual method of holding the work while riveting. In this case, a number of thin plates *A* were to be held together by two rivets *I*. They were, therefore, arranged in stacks of the required number, the rivets with their washers were inserted, and then the stacks were placed on the fixture two at a time. The fixture consists of a base *B*, stud *C*, clamp *D*, two sliding jaws *E* with the necessary binding screws, and plugs *F* for supporting the rivets. In use, a stack of plates was placed on each side of the stud *C*, as shown, and the clamp *D* was tightened just enough to hold the plates *A* in place while the sliding jaws *E* were brought up to force



Fixture for supporting Thin Plates while riveting

all the plates against the stud. The plates were then securely clamped in place by tightening the nut *G*, and the rivets were headed by using the upsetting tool *H* and a hammer in the usual manner. F. SERVER

GRINDING NARROW PARALLEL STRIPS

The writer agrees with "A Grinder," in the October number of MACHINERY, that the best grade of wheel is the Norton 38-46 G, 7- by ½-inch face, for he has successfully ground work only 0.008 inch thick with it. But even with this wheel very thin pieces will become heated and warp, because the wheel becomes glazed and polishes, instead of cutting, before one cut is taken over the job. To prevent this glazing, slots ¼ inch deep, ⅛ inch wide, and about 1½ inch apart should

be cut along the cutting edge of the wheel. These slots break up the continuity of the cutting edge and it does not glaze so rapidly. They also act as a fan and keep the work cool while grinding.

Another cause of warping is the attempt to grind a piece that is not flat. A thin piece that is not flat will be pulled down on the magnetic chuck and the wheel pressure will straighten it out. But thicker pieces, when the power is turned off, spring back again into their original form. A piece that is not flat should be peened with a hammer on the low spots; this will draw it down and flatten it. The piece must not be hammered on the high spots, as that is likely to break it. Hammer dents must not be deeper than the amount of stock to be removed. A parallel smaller than the one being ground should be placed on the left-hand side of the piece. This prevents the wheel pressure from pushing the piece off the chuck. Another good stunt is to place the job either diagonally or endwise, so that the wheel will have as short a traverse cut as possible.

The writer has also used slotted wheels, with great success, on internal work. In these days of war orders, labor troubles, and shortage of materials, most manufacturers are experiencing difficulty in obtaining enough wheels of the correct grade and grain. Anyone who has had to use a hard-grade, fine-grain wheel for grinding a high-speed bushing has realized how quickly a wheel will glaze, polish and heat the job, instead of cutting free and fast. This tendency to glaze may be prevented by taking an old hacksaw (one that is of no more use for cutting steel) and cutting about six zigzag shallow slots in the wheel. One of the writer's regular jobs is to grind piston gages, 3.790 inches in diameter, on a No. 22 B. & S. internal grinder. He uses a two-inch spindle fitted with a bushing, so that he can use up the old H and G wheels from the surface grinders. These gages are roughed, then left standing to shrink, and finished on a surface plate. An H or G wheel is used until the job is within 0.0015 inch of finished size, and then a hard fine-grade slotted wheel is put on and the work is finished. The wheel will not glaze and polish the job out of round, but will cut free and at the same time give that "mirror" finish so much desired in gages.

Detroit, Mich. R. DREW, JR.

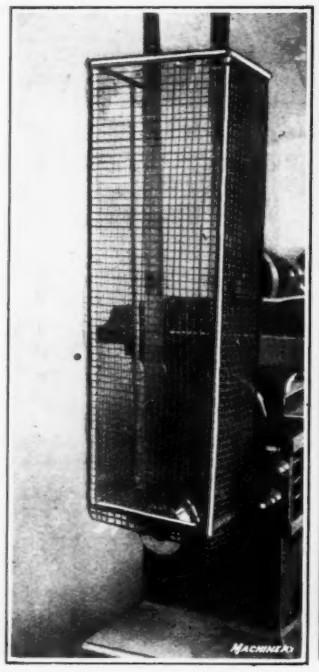


Fig. 1. Guard for Belt on Column Shaper

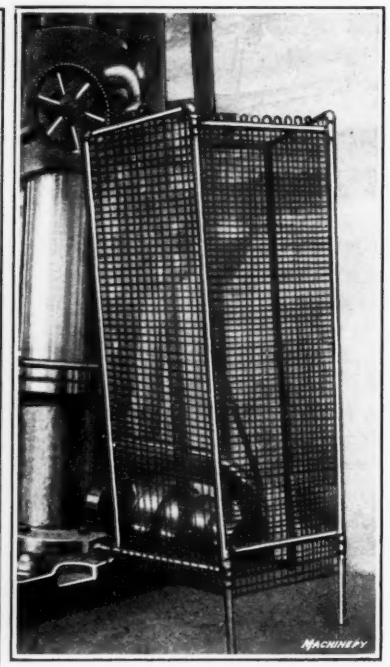


Fig. 2. Guard for Belt on Radial Drilling Machine

EPICYCLIC GEAR PROBLEM—CORRECTION

Permit me to call your attention to an error in the solution of the problem in epicyclic gearing given in the December number. The correct analysis in chart form is as follows:

	M	*N*	*P*	*A*
Wheels locked.....	+50	+50	+50	+50
Arm stationary and *M* returned to original position..	−50	$+\frac{120}{90}\times 50$	$-\frac{120}{40}\times 50$	0
Arm stationary and *M* turned thirty-six times, as shown by arrow *C*.....	−36	$+\frac{120}{90}\times 36$	$-\frac{120}{40}\times 36$	0
	−36	+164 2/3	−208	+50

The arm *A* and gear *M* are moving in opposite directions with velocities of 50 and 36 R. P. M., respectively. This gives 86 R. P. M. as the rate of the gear *M* relative to arm *A*, while the statement published gives it as 36 R. P. M. only. The gear *M* makes 164 2/3 R. P. M. in the direction of the arrow *B*, while *P* makes 208 R. P. M. in the direction of arrow *C* in the illustration appearing in the December number.

Fitchburg, Mass. V. CHARUSHIN

A POINT IN GUARD DESIGN

One of the strongest arguments used against the guarding of belts and pulleys is the inconvenience caused by the guard, which has a tendency to curtail production. This point is especially noticeable when the guards are so arranged as to protect cone pulleys and shifting belts. It is possible, however, to arrange guards for cone pulleys so that the belt may be shifted as easily as if the guards were not present, and yet the opening and closing can be made so convenient that the operator can perform the movements almost without thinking and with practically no loss of time. Fig. 1 shows the application of a guard to the standard column shaper in which the cone pulley is on the side rather low down in a somewhat dangerous position for anyone who may be obliged to pass the moving belt. The guard shown is made of ½-inch pipe and fittings, and the two flanges screwed to the column are the only means of support. Two tees with the threads drilled out are hung from the flanges, and by this means it is possible to swing the entire guard toward the rear out of the way.

Fig. 2 shows a guard for the 4-inch belt of a radial drilling machine which is constructed in much the same manner. The panel to the left is the only stationary one, and the other two swing on the drilled out tees. Support is given by one flange on the base of the machine and the extension of one pipe which is set into the concrete floor. The guard is shown partly open and two legs may be seen resting on the floor, which provision is made on account of the extra size and weight. These two guards are typical of what might be done toward combining protection and convenience at a minimum cost. They pass the rigid New York state requirements and, furthermore, offer no obstruction in the way of keeping the floor clean about the machine.

Middletown, N. Y. DONALD A. HAMPSON

WORKING GERMAN SILVER

In the How and Why section of the November number of MACHINERY, a correspondent says that he has had trouble annealing German silver, and the matter was referred to readers who have had experience with this metal. The best grade of German silver consists of four parts copper, two parts nickel, and two parts zinc, and is the best alloy for table silverware. In late years, many alloys bearing the name German silver have been placed on the market; and while many stand the test of common manufacturing operations, now and then trouble like that mentioned is experienced. While the trouble may be in the annealing, the writer would suggest that first of all the die used in the first drawing operation be examined. The edge of this die should be kept just as smooth as possible by polishing it at least every two or three thousand pieces with the finest emery or crocus cloth; the die should then be washed with gasoline or blown out with compressed air, so that not the slightest bit of stone will be left in it.

The gage of the metal being worked is not given, but any German silver under 0.045 inch should draw and anneal without much trouble if worked under good conditions. When the edge of the drawing die becomes rough from long use, or insufficient drawing solution is used, or there are dirt, steel chips, etc., in the solution, tiny scratches will appear on the side of the shell as it is drawn over the edge of the die. These scratches will become deeper until the edge is stoned off and polished. When this work goes to the annealing oven and the heat expands the metal, these scratches slit or crack open. Unless the shell is very deep or of peculiar shape, a shell of this size can and should be drawn in one operation. The writer has drawn German silver shells four inches deep and three inches in diameter, with flaring sides and bulging bottom, in one draw.

If a shell drawn under ideal conditions, with perfectly smooth sides, is brought red hot from the oven and immersed in cold or running water, the sides may crack, as the cold water chills the metal too quickly. The shells should be cooled in warm water or in the air. In annealing work of this kind, the following method has been used with success. Bring the furnace to about 1500 degrees F., then shut off all fuel and the blower, and fill the furnace with the work, which has been placed in pans or trays made for the purpose. As the furnace cannot become hotter, there is no chance whatever of the work burning; and as it is slowly cooling, the shells will heat and cool with the furnace, and thus anneal perfectly.

Cracks may also be caused by drawing the shells too dry or by the use of a poor lubricant; try good, clean lard oil and use plenty of it—if there is virtue in lard oil, get it. A solution of soap, warm water and lard oil may also be tried. This solution is formed by dissolving common hard washing soap in warm water and then adding an equal quantity of lard oil. If the cracking continues, the shell should be nickel-plated before it is annealed, just a slight nickel wash; brass plating is just as good. The writer sees no reason why this trouble should not be stopped at once, and thinks that if a good grade of alloy, say Coe brass branch German silver, is used under these conditions, there will be no more trouble with the cracks.

There is a hydraulic process of shell drawing in which any shell can be drawn in one operation. As the principle is so different from power-press shell drawing, the required stretch of the metal being distributed evenly over the entire area of the blank, a metal of very low tensile strength can successfully be drawn by this process.

Pittsfield, Mass. G. R. SMITH

SOLVING EQUATION FOR SPIRAL GEARING

On page 346 of MACHINERY for December, the following equation was given:

$$R \sec \alpha + \operatorname{cosec} \alpha = k,$$

in which $R = 3$ and $k = 5.714$, and in which α is known to be in the neighborhood of 45 degrees. The equation was solved by the method of repeated trials, and it was found that α was equal to 46 degrees, 6 minutes. The above equation can also be solved in a simpler and somewhat more elegant way. Let:

$$\alpha = 45 \text{ degrees} + \delta$$

or, in radians:

$$\alpha = \frac{\pi}{4} + \delta$$

Then,

$$\sin \alpha = \sin \frac{\pi}{4} \cos \delta + \cos \frac{\pi}{4} \sin \delta$$

and

$$\cos \alpha = \cos \frac{\pi}{4} \cos \delta + \sin \frac{\pi}{4} \sin \delta$$

Now δ is a small angle. Consequently, we can write, without introducing an appreciable error:

$$\sin \delta = \delta, \text{ and } \cos \delta = 1,$$

and, furthermore,

$$\sin \frac{\pi}{4} = \cos \frac{\pi}{4} = \frac{1}{\sqrt{2}}$$

Then,

$$\sin \alpha = \frac{1 + \delta}{\sqrt{2}}, \text{ and } \cos \alpha = \frac{1 - \delta}{\sqrt{2}},$$

or, using the reciprocals:

$$\operatorname{cosec} \alpha = \frac{\sqrt{2}}{1 + \delta}, \text{ and } \sec \alpha = \frac{\sqrt{2}}{1 - \delta}$$

Substituting for α in the original equation:

$$\frac{R\sqrt{2}}{1 - \delta} + \frac{\sqrt{2}}{1 + \delta} = k$$

and, simplifying,

$$\sqrt{2}(R + R\delta + 1 - \delta) = k(1 - \delta^2)$$

By substituting the given values and simplifying:

$$\delta = 0.0201 - 2.0201\delta^2$$

But δ is small and, hence, δ^2 is still smaller, so that $\delta' = 0.0201$ must be very near the value of δ. By substituting δ' for δ in the second member of the right-hand side, we have:

$$\delta = 0.0201 - 2.0201 \times 0.0201^2 = 0.0192 \text{ radian},$$

from which $\delta =$ 1 degree, 6 minutes, and $\alpha = 46$ degrees, 6 minutes, which is the same value as obtained by the other method.

Chicago, Ill. NIKOLA TRBOJEVICH

The above solution is unquestionably more mathematical and interesting from the mathematician's point of view than the trial-and-error method, but it is doubtful if it is to be recommended for practical purposes, for two reasons: In the first place, the method is not as easily applied by a man who is not well versed in mathematics as is the more simple trial-and-error method; and, in the second place, as far as the trained mathematician is concerned, it is doubtful if he can save any time by the proposed method, because the arithmetical work of solving the equation, as outlined above, is probably greater than the arithmetical work involved in making about three or, at most, four trial solutions, which is all that a mathematically trained man would need. Nevertheless, the above method should prove interesting to all students of mathematics, showing how, by means of mathematical formulas, a simple expression can be obtained for solving an equation which, on the face of it, appears impossible of a simple mathematical solution.—EDITOR.

BORING STRAIGHT HOLES ON A WORN LATHE

When the writer was passing through a repair shop recently, he saw a good lathe man boring a hole that tapered because the ways or vees of the lathe were not in line with the head. Had the man turned his boring tool upside down and bored from the other side, with the machine running the same, he would have obtained a straight hole. This is due to the fact that in boring the tool approaches the center line as it feeds into the hole; therefore, when the tool is turned over and used at the back of the hole, it will recede from the center as it feeds along. Consequently, if, because of a worn spindle, ways or vees, or for some other cause, a tool approaches the center when a hole is being bored, it will move a corresponding distance from the center when it is turned, and the hole is rebored and will thus produce a straight hole. Should the holes bored be larger at the back, however, the problem is more difficult. While the same result will be obtained by turning the tool, care must be exercised and stock should be left for cleaning up.

Lancaster, N. Y. EDWARD BINGEMANN

"LAPPING" THREADS WITH ACID

It often happens that after an important screw has been cut, hardened, and lapped to size, it will still fit too tight in places. This may be caused by unequal expansion and contraction during the hardening process, or it may be through some inaccuracy in lapping; whatever the cause, the fact remains that in hardened screws this trouble is the rule rather than the exception. In some cases it will be of small consequence, and a wrench may be used to force the screw; but in gage screws, jig screws, adjusting screws, and in all high-grade work it becomes a troublesome matter. This evil may be remedied, however, by cleaning the screw in hot soda water, then dipping it for about a minute in a bath of nitric acid, and on its removal immersing it in water. After it is dried, it should be tried in the tapped hole. If the screw is still too large, the process should be repeated until the desired fit is obtained. This method provides a very good "acid lap" that will be found convenient for many purposes in and about the shop.

Plainfield, N. J. J. B. MURPHY

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

STRAIGHTENING PIPE

W. H. J.—I am working in the oil field and often need a pipe-straightening machine to straighten pipe of all sizes up to 10 and 12 inches diameter. One of our chief troubles is bent pipe. Can you offer any help?

A.—We know of no means for straightening bent pipe other than pipe bending machines, which may, of course, be employed for taking the kinks out of bent pipes. The pipe bending machine, however, cannot be used for field work on such large sizes as 10 or 12 inches. The only means we can suggest for straightening large pipe is the lathe, lever or screw and test method commonly employed in straightening shafting. The question is referred to readers for suggestions.

LETTERING ON DRAWINGS

D. W. B.—The question of conventions and lettering to be used on drawings has come up, and I would like to know if there is some definite form and style adopted as a standard of practice. One of the mooted questions is the use of small letters in italic lower case, or all caps. Some argue that the small letter is more rapidly made and is easier to form, while others claim that legends in all caps are used more commonly in mechanical drawing and in architectural and furniture designs.

A.—It is generally conceded that legends on drawings can be made neatly and rapidly in italic lower case. The practice, however, is by no means uniform, and small caps are often used by draftsmen. Simplicity should be the keynote in all mechanical drawings, and the use of ornate headings and lettering generally should be tabooed. Whether or not small caps or italic lower case are to be preferred for legends is a question that has not been decided by general use.

PLANED AND BORED CROSSHEAD GUIDES

R. T. R.—Will you please explain the advantages and disadvantages of the two types of crosshead guides shown in Figs. 1 and 2, and tell why the style shown in Fig. 1 is the general type of guide used on locomotives, and why that shown in Fig. 2 is generally used on stationary engines? Is the type shown in Fig. 2 a cheaper guide for the reason that it may be machined when the cylinder is bored?

A.—The type of crosshead and guide shown in Fig. 2 is cheaper than that shown in Fig. 1 for the reason that the guides may be bored when the cylinder is bored and the crosshead may be turned in a lathe instead of being planed. The bored type of crosshead guide is not, however, suitable for locomotive use. In the first place, the guide and frame cannot be cast integral as is common practice in stationary steam engine construction. In the second place, the crossheads of a locomotive need to be restrained in a vertical plane because

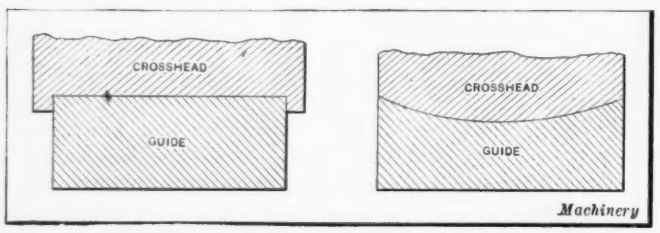


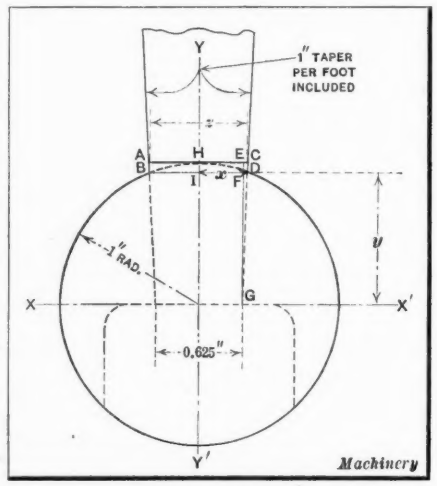
Fig. 1. Planed Crosshead Guide Fig. 2. Bored Crosshead Guide

of the turning moments set up in the piston, crosshead and connecting-rod due to uneven track, curves and loose connections. These turning moments are negligible in a stationary engine and are restrained by the connecting-rod and crank-pin.

A GEOMETRICAL PROBLEM

W. A. W.—Referring to the illustration, please show process of solution in finding the values of z and y.

A.—Draw AC parallel to BD and tangent to the circle; draw GE parallel to the center line, and consequently perpendicular to AC and BD. Since GE = the radius = 1 inch, and since a taper of 1 inch per foot = 1/12 inch per inch, $EC = 1/2 \times 1/12 = 1/24$ inch, and $HC = 1/2 \times 5/8 + 1/24 = 17/48$ inch. We now know (or can find) all the parts of the triangle EGC, and we know, therefore, the angles of the similar triangle FGD, but we know nothing in regard to its sides. Hence, neither FD nor FG can be found by trigonometry or geometry; but these sides can be found by applying certain principles of analytical geometry. The equation of a straight line through a point is $y = mx + b$, where y = ordinate, x = abcissa of point; m = tangent of the angle which the line makes with the X axis, and $b = y$ intercept. Thus, the equation of the line GC through point D whose coordinates are x and y with reference to the axes X-X¹ and Y-Y¹ is $y = 24x - 7.5$, and the equation of the circle is $x^2 + y^2 = 1$. Making these two equations simultaneous and substituting the value of y from the first equation in the second equation, we have $2308x^2 - 1440x + 221 = 0$, from which $x = id = 0.351508$ inch. Substituting this value of x in the first equation, $y = 24 \times 0.351508 - 7.5 = 0.93619$ inch = GF. Therefore, $z = BD = 2x = 2 \times 0.351508 = 0.70302$ inch.



A Geometrical Problem

J. J.

INTERPOLATING TO SECONDS

H. J. L.—Suppose the natural tangent is 0.63154; how can I find the angle in degrees, minutes and seconds, using the table in MACHINERY'S HANDBOOK? Also, in using a sine bar and getting a dimension, how can I get the exact angle carried out into seconds?

A.—Referring to page 188 of MACHINERY'S HANDBOOK, the angle whose tangent is 0.63154 is seen to lie between 32 degrees, 16 minutes (the tangent of which is 0.63136) and 32 degrees, 17 minutes (the tangent of which is 0.63177). The difference between these two values is 0.00041; the difference between the tangent of the smaller angle and the given tangent is 0.00018; and the difference between the two angles in the table is 1 minute = 60 seconds. Assume that the following proportion is true, as it will be for practical purposes, $x : 60 = 0.00018 : 0.00041$, from which $x = \dfrac{60 \times 0.00018}{0.00041} = 26$ inches. Therefore, the rule is: Find two consecutive functions in the table, one of which is greater and the other less than the given function, and take their difference. Find the difference between the given function and the function corresponding to the smaller of the two angles; multiply this difference by 60 and divide the product by the difference previously found. The quotient will be the number of seconds sought.

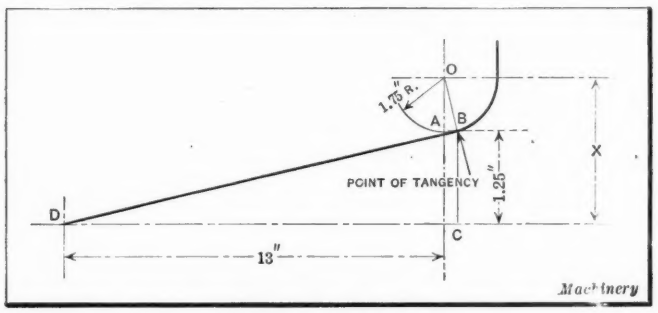
It is not possible to find an angle correct to seconds by using the sine bar, and such extreme accuracy is entirely unnecessary in practical work. If the sine bar and the measurements are sufficiently accurate to determine the angle to a single minute, the result may be considered refined enough for practical purposes.

J. J.

PROBLEM IN DESIGNING DIES

F. A. R.—The illustration shows a problem in connection with the designing of dies for forming a sheet-metal piece. Please show how to find the distance X.

A.—Since the right triangles BOA and BDC are similar, $\frac{AB}{OB} = \frac{BC}{DB}$. Let $AB = y$; then $DC = 13 + y$, and $DB = \sqrt{(13+y)^2 + \left(\frac{5}{4}\right)^2}$, since $1.25 = \frac{5}{4}$. $OB = 1.75 = \frac{7}{4}$. Substituting these values in the above proportion, $\frac{\frac{y}{7}}{\frac{5}{4}} = \frac{\frac{4y}{7}}{\sqrt{(13+y)^2 + \left(\frac{5}{4}\right)^2}}$. Squaring both sides of this equation and clearing of fractions, $256y^4 + 6656y^3 + 43664y^2 - 1225 = 0$. Solving this equation by Horner's method, $y = 0.165411$. $OA = \sqrt{1.75^2 - 0.16541^2} = 1.74217$. Therefore, $X = 1.25 + 1.74217 = 2.99217$ inches. To prove that the value of y is correct, compute DB, obtaining $\sqrt{13.16541^2 + 1.25^2} = 13.2246$. Then, in the above proportion, $\frac{AB}{OB} = \frac{0.16541}{1.75} = 0.09452$, and $\frac{BC}{DB} = \frac{1.25}{13.2246} = 0.09452$. J. J.



Problem in designing Dies

WHY A SAFETY VALVE IS IN EQUILIBRIUM

C. M. G.—My text-book on mechanics states that a couple produces or tends to produce rotation only, and that it can be balanced only by another couple that tends to rotate the body in the opposite direction. How can this statement be reconciled with the forces acting on a safety-valve lever? Here the steam pressure acts upward and the weight acts downward, thus forming a couple; where is the other couple?

A.—You have not taken into account all the forces acting on the lever. Referring to the illustration, the force P acting upward represents the steam pressure, and the force W acting downward represents the weight. The lever would turn under the action of these two forces if it were not for the pin O. As the bar presses against the under side of this, the pin reacts downward an equal amount; this force is represented by R. We may imagine that the pin O is removed and that equilibrium is maintained by means of a force R acting on top of the lever in a vertical line through the center of the pin. Then, force P must equal $R + W$, since it supports both W and R, both acting downward. P may, therefore, be considered as made up of two forces, one equal to R and the other equal to W, and both acting upward. This force R combined with the downward force R forms a couple, the arm of which is OA, and which tends to turn the bar counter-clockwise; W combined with the force (weight) W forms another and equal couple, the arm of which is AB, and which tends to turn the bar clockwise; the two couples thus neutralize each other. Taking an actual case, suppose $W = 28$ pounds, $OA = 4$ inches, and $AB = 38$ inches. Then, taking the center of moments at A, $R \times 4 = 28 \times 38$, or $R = 266$ pounds. Taking the center of moments at O, $P \times 4 = 28 \times (38 + 4)$, or $P = 294$ pounds $= 266 + 28 = R + W$, as it should. Your assumption of a couple formed by P and W is wrong, because a couple consists of two equal parallel and opposite forces, and P is greater than W. Note that the weight of the bar (lever) has been neglected. J. J.

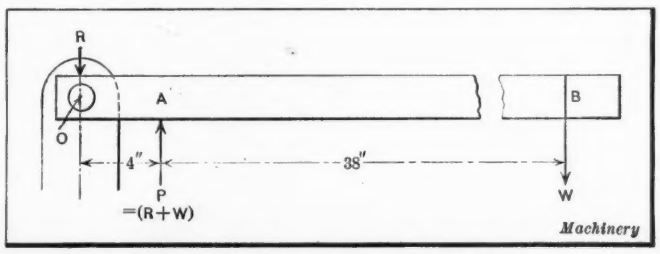
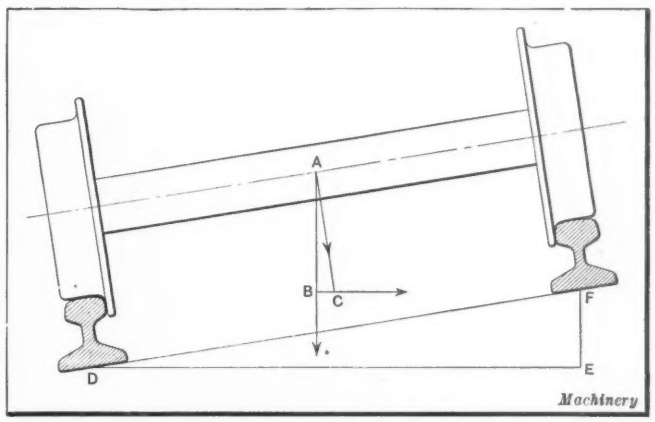


Diagram showing Principle of Safety Valve

ELEVATION OF OUTER RAIL ON A RAILWAY CURVE

B. H. H.—I notice that on all railway curves the outer rail is higher than the inner rail, and I am told that this counteracts the centrifugal force. Will you please explain? Also, what effect does the weight of the train have in determining the amount of elevation?

A.—In the September number of MACHINERY, page 63, it was shown that when a body moves in a circle, the centrifugal force is expressed by the formula $F = \frac{Wv^2}{gR}$, in which F = centrifugal force, in pounds; W = weight of moving body, in pounds; v = velocity of moving body, in feet per second; $g = 32.16$; and R = radius of circle or curve, in feet. Now, when a train goes around a curve, it is deflected from the straight line in which it would ordinarily move and is kept to the rails by reason of the flanges of the outer wheels pressing against the outer rail; this pressure is the centripetal force, and acts in the direction BC (see illustration). The weight on a pair of wheels acts vertically downward in the direction AB; the resultant of these two forces is represented by AC. When one of the rails is elevated until the line DF, which is parallel to a line touching the tops of the rails, becomes perpendicular to the line of action of the resultant AC, the centripetal force BC will be exactly balanced by the tendency of the wheels and their load to slide in the direction FD, and there will be no pressure between the flange and the rail. Since the triangles ABC and DEF are similar, $AB:BC = DE:EF$, or $W:F = b:h$, when $b = DE$ and $h = EF$; whence, $h = \frac{Fb}{W}$. Substituting the value of F given above, $h = \frac{Wv^2}{gR} \times \frac{b}{W} = \frac{bv^2}{gR}$. If b is in inches, h is also in inches. Note that the weight of the train has no effect on the elevation of the rail. Suppose the train is running fifty miles per hour around an eight-degree curve, and that b, or the distance from center to center of rails, is 4 feet, 8.5 inches, or 56.5 inches. The elevation is then $h = \frac{56.5\left(\frac{50 \times 5280}{60 \times 60}\right)^2}{32.16 \times 716.2} = 13.2$ inches. The radius of an eight-degree curve is 716.2 feet. J. J.



Elevation of Outer Rail on Curve

LOCATING AND BORING HOLES IN A SINE BAR

C. W. H.—I read with interest the article in the October number by Donald Baker on sine bars. I know comparatively little about precise tool work, but venture to ask the question why, instead of boring the soft steel plugs in the lathe, the bar was not set up in the milling machine vise and the holes bored with a vertical milling attachment, using the lead-screw to set off the distance of 5 inches. Would not this method be accurate in locating the holes within limits of 0.0001 inch?

Answered by Donald Baker, Montreal, Canada

A.—It is possible to locate and bore the holes in the sine bar on a milling machine by clamping the bar in a vise and using the vertical attachment and the feed-screws; or it might be clamped to the table or on an angle-plate. But in the case of holding in a vise, for instance, extreme care must be taken to insure that the vise is set up perfectly square in all directions with the spindle. The lead-screw of the ordinary milling machine cannot be depended upon for precision work, and to secure accurate spacing with one would be more or less of a cut-and-try method. At best I would not expect to get results much closer than $\pm$ 0.0003 inch. On the other hand, if we button up a soft plug, as described, we have fewer difficulties to contend with. The flat sides of the bar having been ground accurate and the two edges rough-ground, the buttons are put in place and located, using Johanssen gages, if at hand. Micrometers may be depended upon if they are correctly and carefully used. No special pains need be taken to set the buttons closer than 0.001 or 0.002 inch of parallel with the edges of the bar. The next step is to true up a lathe faceplate and strap the sine bar in place and indicate one of the buttons carefully. The final indicating is done after the bar has been securely clamped and the lathe is running at the correct boring speed. This precaution is essential, for if the lathe is out of balance, the truth of the boring operation will be affected. After both holes have been bored, the buttons are inserted and finally inspected for the distance apart. If the distance apart is found correct, the grinding of the edges follows, which is done on the surface grinder, setting up the bar on an accurate angle-plate and using an indicator or parallels to set the buttons level. No matter what method is employed, however, the human element is an important factor in bringing work of this kind to a successful conclusion.

THE RECOIL OF A GUN

E. F. R.—I enclose a clipping regarding the "kick" of a gun. Will you please show me how the recoil energy is calculated from the formula? Please note that the author states that the recoil energy of a 12-bore shotgun is nearly twice that of the army rifle, and that a trapshooter will take the kick without a murmur, while a soldier is sensitive to the kick of a rifle and the limit is 300 rounds a day. Is his explanation of why this is so reasonable?

A.—The formula mentioned is $vW = Vw + 4700W'$, in which v is the recoil velocity of the gun, and V is the muzzle velocity of the bullet, both in foot-seconds; W is the weight of the gun, w is the weight of the bullet, and W' is the weight of the charge, all in grains. The formula applies only to the U. S. army rifle; for other weapons and ammunition, the constant, 4700, would need to be changed. According to the Encyclopedia Britannica, for the present U. S. army rifle, $W = 8\frac{1}{2}$ pounds, $V = 2600$ foot-seconds, $w = 150$ grains, and $W' = 50$ grains. Substituting these values in the above formula, $v = \frac{2600 \times 150 + 4700 \times 50}{8.5 \times 7000} = 10.5$ foot-seconds. The recoil energy is found by substituting the values of v and W in the expression for kinetic energy, $\frac{Wv^2}{2g} = \frac{8.5 \times 10.5^2}{2 \times 32.16} = 14.6$ foot-pounds.

Regarding the explanation as to why the kick of a shotgun is not felt so much as the kick of a rifle, it must be remembered that the force of a blow depends largely on the distance through which the moving body passes in coming to rest; the shorter the distance, the greater the blow. According to the author: "The shotgun is fired with the muscles tense and the body moving—in other words, the shot is taken by a set of tense springs; the rifle is fired with the muscles relaxed, fired deliberately. The shotgun has also a straighter stock, thus bringing the line of direction nearer to the direction of recoil." Suppose that the gun were placed in a vertical position with the stock resting on a block of wood that, in turn, rested on the platform of a scale; the force of the recoil could then be measured. Suppose, further, that a set of springs (or some yielding substance) were placed between the block of wood and the scale platform; the force of the recoil would then be found to be considerably less. Assuming that the author's statements regarding the manner of firing are right, the stock of the rifle rests more firmly against the bones of the shoulder than is the case when the shotgun is fired; consequently, even though the recoil energy of the shotgun may be greater, the gun moves through a greater distance and the resulting kick may be less than with a rifle. The writer is inclined to doubt that a trapshooter will ever fire 300 rounds in a day.

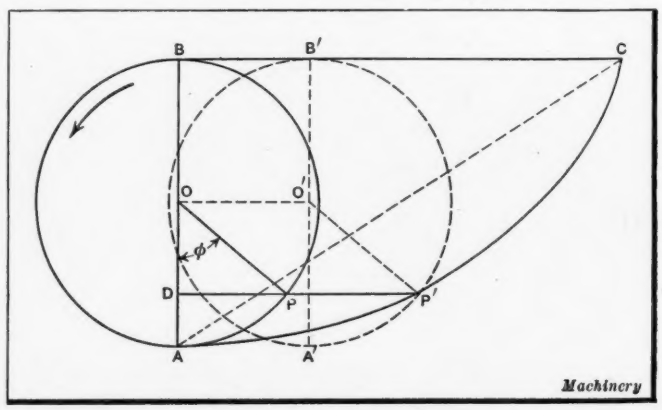
J. J.

LINE OF QUICKEST DESCENT

S. I. N.—Suppose that a ball is to roll without friction from a point C to a point A; what must be its path in order to get to A in the shortest time? I claim that the path will be a straight line from C to A, because the velocity of the ball when it gets to A will be the same, whatever path it takes, and a straight line is the shortest distance between two points; but a friend tells me that if the ball follows a certain curved path, it will reach A more quickly. If this is so, what is the curve?

A.—If the ball rolls from C to A along the straight inclined plane CA, the acceleration will be uniform throughout the entire distance. If, however, the ball takes a curved path, such as $CP'A$, the acceleration will be variable, and a velocity that nearly approaches the final velocity at A will be attained for some time before the ball reaches A. It will thus be apparent that there must be some curve that will take the ball from C to A in a shorter time than if it follows some other path. The curve is called the brachistochrone, a word derived from the Greek and meaning shortest time. It is commonly called the cycloid, and is the curve that would be traced by a point on the circumference of a circle rolling on a straight line without slipping. Thus, suppose that a circle having the diameter BA rolls from B toward C, turning in the direction indicated by the arrow; the path (locus) of the point A will be the half cycloid $AP'C$, and BC will be equal in length to half the circumference of the circle. For any position of the circle, as B', the center will be at O'; the point A will be at P'; and $BB' =$ arc $AP = OO'$. To construct the cycloid, divide the semicircle APB into any convenient number of parts; suppose that one of these parts is AP. Through P draw DP' parallel to BC; draw OO', and make it equal in length to the arc AP. With O' as a center and OB as a radius, describe a circle cutting DP' in P'. Note that angle $A'O'P' = AOP$ and that $POO'P'$ is a parallelogram; hence, $PP' = OO' =$ arc AP; $DP = r \times \sin \phi$; and $DA = r\,(1 - \cos \phi)$. Also, $DP' = r\,(\sin \phi + \phi)$, in which ϕ is the angle AOP, in radians. Therefore, by using a table of trigonometric functions, the values of DA and DP' may be readily calculated for any angle desired.

J. J.



Curve of Quickest Descent

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

AJAX SCRAP RECLAIMING ROLLS

The waste represented by the scrap heap may be an important item especially at the present time owing to the relatively high cost of materials. When it is realized that practically all of the large railroads dismantle from a few hundred to several thousand cars annually and that there are many companies in other lines of business that accumulate thousands of tons of scrap yearly, the importance of reclaiming at least a certain percentage of this material is evident. In most cases it would not be considered practicable to install and operate a regular rolling mill but a considerable saving could be effected by the use of reclaiming rolls such as are illustrated in Figs. 1 and 2 which show two views of a recent design that has been brought out by the Ajax Mfg. Co., Cleveland, Ohio. This machine is designed for reclaiming such scrap as arch bars, brake staffs, brake levers, tension rods, scrap ends from forging operations, etc., by heating the scrap and re-rolling it into bars of stock from which bolts, car fittings, or similar parts may be made.

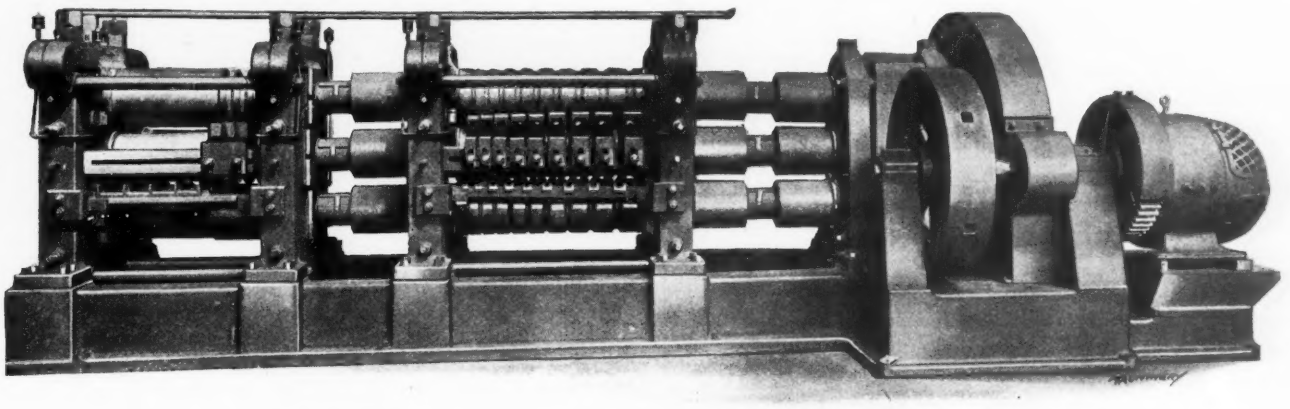


Fig. 1. Reclaiming Rolls set up to roll Round Stock in One Set of Housings and Flat Stock in Other Set

In general design the reclaiming rolls resemble very closely a modern rolling mill. The working parts are mounted on a massive cast-iron base which is cast in one piece. There are two sets of rolls which are "three-high," where the rolling is done. A detailed view of the rolls and housings is shown in Fig. 3. The cylindical surface of the rolls containing the grooves is 12 inches in diameter and 40 inches long. By using the two sets of three rolls each, it is possible to roll all standard sizes of round bar stock up to 1¾ inch in diameter. Round or square scrap measuring 2½ inches in diameter or width, or scrap of an equivalent section, represents the largest size that may be used. The widest flat stock that can be rolled is 4 inches, provided the thickness is ¾ inch or more; 3¼ inches is the maximum width for stock ½ inch thick, and 2½ inches the maximum width for stock ¼ inch thick. Two sets of rolls, or a total of six rolls, are furnished with each standard equipment; these rolls will be grooved to suit the requirements of the user. Additional rolls can be obtained at any time for any size stock.

The rolls are made of special rolled steel castings. The bearings are of liberal proportions and bronze bushed; they are split to provide adjustment for wear. The roll shafts have independent adjustment horizontally and vertically except the middle shaft which does not require vertical adjustment. The vertical adjustment of the upper roll is obtained by means of studs and set-screws on top of the housing. For the bottom roll the vertical adjustment is obtained by means of taper wedges on which the bearings rest; these wedges are operated by set-screws that project from each side of the housing. Horizontal adjustment of the rolls to align the grooves is obtained by means of bronze taper wedges located between the housings and the shoulders of the rolls at the bearings. These wedges may be seen at the extreme left in Fig. 3. The adjustments referred to do not interfere in any way with the driving of the rolls, because the "crabs" connecting the various units of the shaft do not need to be in accurate alignment.

The main driving pinions are of forged steel and have herringbone teeth cut from the solid. These pinions are mounted in separate housings as illustrated to the right in Fig. 3. The grooves in the rolls are shaped according to the best rolling mill practice. The "break-down" grooves for round stock

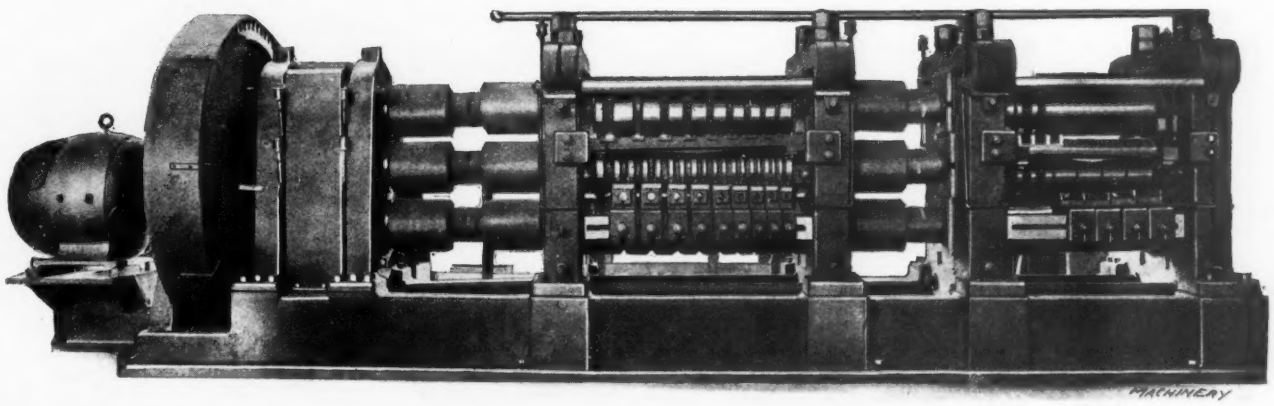


Fig. 2. Opposite Side of Ajax Scrap Reclaiming Rolls shown in Fig. 1

are oval or of "gothic" design. The number of grooves in a set of rolls is varied according to the size of the stock. The best results have been obtained by having the heavy break-down grooves in one set of rolls and the smaller and finishing grooves in the other set. By doing the heavy break-down work in one set of rolls and the lighter finishing work in the other set, the fine adjustment necessary for the finished product can be maintained.

Both the entering and receiving guides (see Fig. 4) are individual units for each groove and can be adjusted to suit any spacing of the grooves. The bracket which holds the receiving guides is also adjustable. The lower guides shown in Fig. 4 are entering guides for oval stock and lead into the round grooves in the rolls. The entering guides for stock entering the oval or gothic grooves, are similar to the entering guides for the round grooves except that they are cast in one piece and have square holes for the bar to pass through so that they do not guide the stock as closely. These reclaiming rolls are equipped either with motor or belt drive. Special care has been taken to cover all gears, and projecting screws at the shaft connections have been avoided.

The machine described in the foregoing is the smaller of two sizes that have been placed on the market. The larger size is similar in design and differs only in regard to capacity. The roll shafts of the larger machine are 14 inches in diameter and 44 inches long on the working surface. These larger rolls will reduce material having a diameter or width of 3½ inches, or scrap of equal section. The maximum widths of flat stock that can be rolled are as follows: for a thickness of ¾ inch,

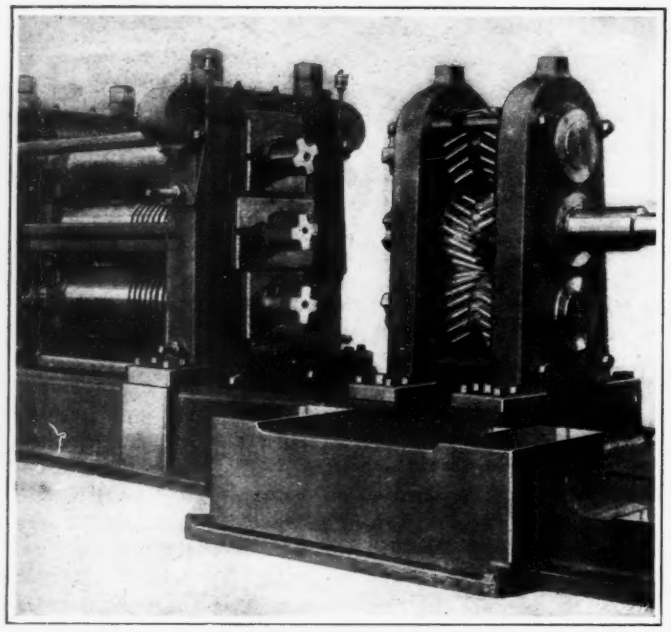


Fig. 3. Close View of Herringbone Driving Pinions, Housings, Bearings and Rolls

5 inches wide; for a thickness of ½ inch, 4 inches wide; for a thickness of ¼ inch, 3 inches wide. Round scrap to be passed through these rolls should be reasonably straight and should be cut to lengths which will roll to the required length. When scrap has holes drilled through it a very good product has been obtained by rolling it at a welding heat. Scrap such as arch bars, brake levers, and other wide flat stock must be split before rolling. This may be done either hot or cold in a splitting shear or splitting blades may be made for two of the rolls on the reclaiming rolls.

The saving that may be effected by the use of these reclaiming rolls is indicated by the following figures. These figures, however, apply to rolls of an earlier design than those described in the foregoing and which lack several advantages of the latest design. These figures are also based on the prices of scrap, stock bar, labor, etc., which prevailed before the war. In one case the average output per day was 5 tons, which was valued at $150. The value of the scrap iron was $75, making the gross earning per day, $75. Deducting a total operating cost per day of $35.70 leaves a net earning of $39.30. The average output includes slack times when the rolls were idle.

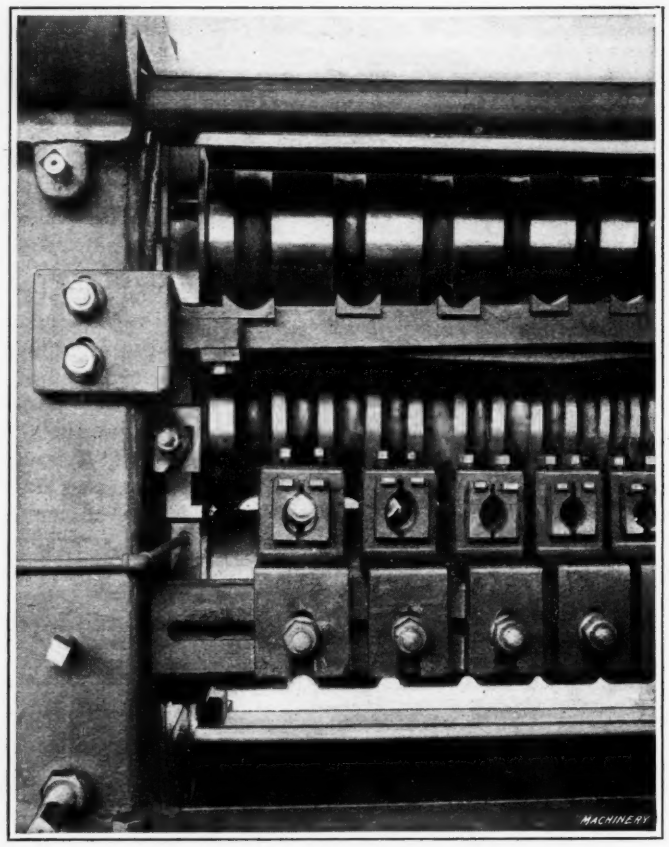
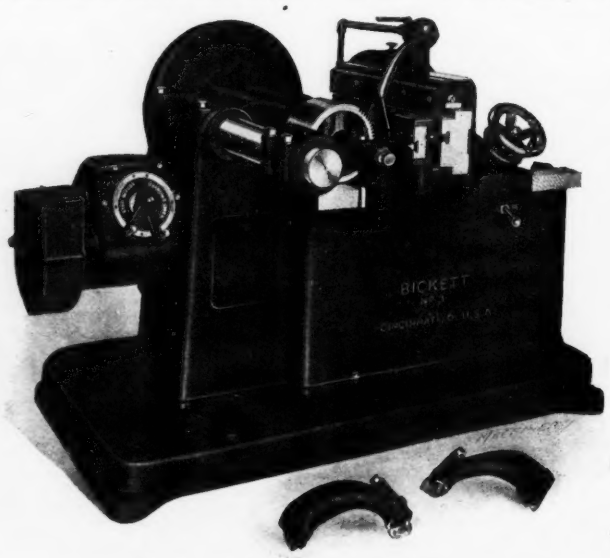


Fig. 4. Close View of Rolls for Round Stock, Guides and Guide-holders

On one of the eastern railroads re-rolled stock is produced at a cost of $3.75 per ton. Reports from various users of these reclaiming rolls representing different periods of time within three years, indicate that the average output of these rolls is about one ton per hour, working time. The product is claimed to equal hot-rolled bar stock.

BICKETT AUTOMATIC GEAR AND RACK PLANER

The automatic gear and rack planer illustrated herewith is a recent product of the Bickett Machine & Mfg. Co., Cincinnati, Ohio. The operation of this machine is somewhat similar in principle to that of a crank shaper in that it has a ram operated by a crank which carries the cutting tools back and forth across the work, but its most distinctive feature is that two tools are used. One of these tools operates on the forward stroke and the other on the return stroke of the ram. The cutter operating on the forward stroke is the roughing cutter. It has corrugated sides and may be forced into the metal at the maximum speed and depth of cut that is practicable with



Bickett No. 3 Automatic Gear and Rack Planer

the best high-speed steel; cuts of 1/32 inch on cast iron are not unusual. The other cutter, which operates on the return stroke, is ground accurately to the exact contour of the gear tooth and takes light finishing cuts.

In order to insure accuracy and prevent chatter when working at high speeds, the work spindle is mounted directly upon a massive bed. This spindle is 4 inches in diameter, 16 inches long, and has a No. 12 B. & S. taper hole. The ram carriage is also mounted directly upon the bed and the ram has a metal-to-metal contact throughout the entire length of its working surface. The in-feed mechanism for the cutter is so designed that the rate of feed gradually diminishes as the cutter approaches the total depth for the tooth space. The cut is heavy at first and then is gradually reduced until the proper depth has been reached, when there is a dwell of the ram carriage for the finishing cut. This diminishing feed prevents uneven strains and gives a fine finish to the tooth surfaces. The cutter ram has a variety of speed changes controlled by a quick-change gear-box and a regulating lever.

The time required to index the work and return the ram carriage to the cutting position is only 1½ second for any width of gear. The clearance required for the cutting tool at the beginning of the cut is only 1/64 inch. A general idea of the performance of this machine will be obtained from the accompanying table, which gives the time required to cut a series of gears ranging from 16 to 4 diametral pitch. The capacity of the machine is as follows: maximum outside diameter of gear, 28 inches; maximum length of rack, 30 inches for one setting, 60 inches for two settings; maximum face width, 8 inches; maximum size of teeth, 4 diametral pitch. A pump and piping for supplying cooling lubricant forms part of the regular equipment. The machine may be driven by means of a regular countershaft, a motor drive with long connection for a leather belt, or a motor drive with a short connection close to the machine for a silent chain drive.

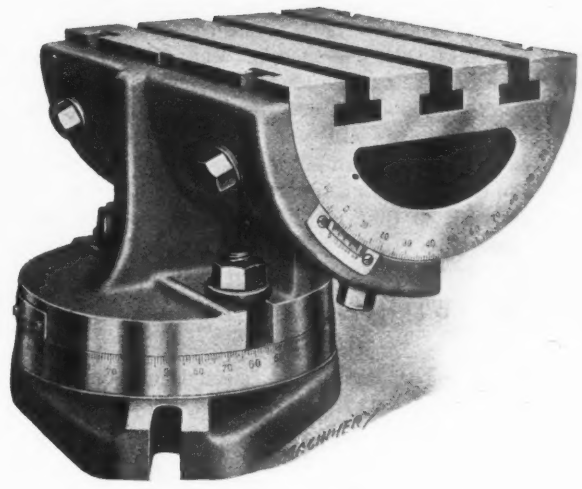
TIME REQUIRED FOR CUTTING GEARS OF DIFFERENT PITCHES

Diametral Pitch	Number of Teeth	Width of Face, Inches	Strokes of Ram Required to Cut Tooth	Speed of Ram, Feet per Minute	Total Time Required to Cut Gear, Minutes
4	40	8	46	90	28
6	48	6	37	90	22
9	54	2	30	90	9
12	60	3	26	90	10
14	84	4	25	90	20
16	112	7	22	90	37

Machinery

UNIVERSAL ANGLE-PLATE

In connection with work on planers, milling machines, shapers, drill presses, grinders, etc., it is frequently necessary to hold parts at an angle, and in some cases one or more adjustments have to be made in order to perform successive operations. For work of this class an adjustable plate provided with suitable graduations not only saves time but insures accuracy, especially when two or more surfaces or holes must be located at different angles. The universal angle-plate brought out by the Boston Scale & Machine Co., 381-389 Congress St., Boston, Mass., is intended for use in machine shops and tool-rooms whenever angular adjustments are required in connection with machining operations. This fixture has an angular adjustment of 360 degrees in a horizontal plane and 90 degrees in a vertical plane. The graduated scales for both vertical and horizontal angular adjustments are provided with verniers which make it possible to set the fixture accurately to a given angle. This angle-plate is especially adapted to jig and fixture work as it is capable of rapid adjustment, and after the work is clamped in position it is not necessary to reset it in order to drill or machine two or more holes or surfaces located at different angles. The various ways in which this angle-plate may be applied will be apparent to those familiar with machine shop and tool-room practice. It is made in three different sizes, with working surfaces measuring 4 by 6, 6 by 8, and 8 by 10 inches.

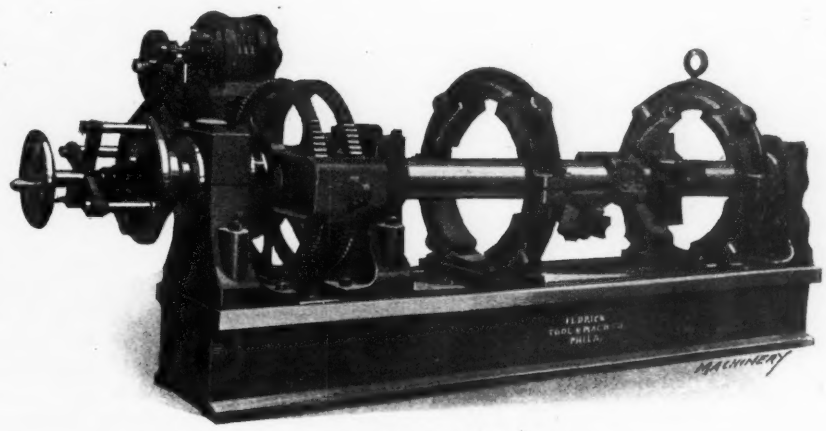


Angle-plate having Universal Adjustment

PEDRICK TUBE BORING AND FACING MACHINE

The tube boring and facing machine described in the following is a recent development of the Pedrick Tool & Machine Co., 3639 Lawrence St., Philadelphia, Pa. This machine was designed for boring torpedo tubes, which is work requiring considerable accuracy. Obviously the machine is also applicable to the boring of various other parts such as cylinders, linings, bushings, or other work which can be held readily in saddles. The machine may also be used for boring pillow blocks, pedestals, and similar parts. The boring-bar is supported in three pedestals at a fixed height above the bed. These pedestals are so designed, however, that spacing blocks may be used to raise them if this is necessary, without interfering with the alignment of the boring-bar or the other mechanism. Large bushings in the pedestals provide bearings for the boring-bar. The latter is revolved from an electric motor through compound gearing, so arranged as to permit speed variations to be obtained. A belt drive may be employed if desirable.

The cutter-head travels along the boring-bar, the same as in the regular portable machine made by this company, and it is controlled by an automatic reversible feed having three changes. The saddles for holding parts to be bored may be plain, as shown in the illustration, or equipped with four adjusting screws when a miscellaneous line of work is to be handled. These saddles may be adjusted along the bed and are held in position by stud bolts engag-



Pedrick Tube Boring and Facing Machine

ing two T-slots, which extend the full length of the bed on both sides. The cutter-head has four arms for carrying a like number of tools. The facing arm seen on the bar in the illustration is for facing the flanges or ends of tubes or cylinders. This machine is intended for use in railway shops, repair shops, in shipyards where the boring of sleeves and tubes is done constantly, and in many other kinds of industrial plants. The machine has a long boring travel for its size and is self-contained, so that it can be placed in any part of a shop or yard.

HARRIS AUTOMATIC HOB SHARPENING MACHINE

The grinding machine to be described is one of the special types built by the H. E. Harris Engineering Co., 1041 Broad St., Bridgeport, Conn. This machine operates automatically after the hob is in position, which insures sharpening hobs accurately, uniformly, and at a certain fixed speed. When hobs are ground by hand operation, the teeth are sometimes burned by attempts to grind too rapidly and one series of teeth may be ground below another, thus causing an uneven distribution of the work of cutting. This machine has been designed to avoid defects of this kind.

The wheel spindle is mounted in ball bearings carefully adjusted to eliminate end thrust and insure steady operation. The spindle bearings are on a horizontal slide, which is adjusted with a micrometer screw. This horizontal slide is carried by a vertical slide, which also has a micrometer screw to insure accurate adjustment. With this arrangement the wheel may be set both horizontally and vertically with considerable accuracy, and the machine may be adjusted for any size or shape of wheel within its range and for grinding the faces of the teeth to any degree of rake required. By applying an extra attachment of simple design, this machine is adapted for grinding either right- or left-hand spirally fluted hobs, as well as those having straight flutes. The machine is also adapted for grinding taps as well as for various other tool grinding operations.

The work-table is moved back and forth with a uniform motion by a cam in the body of the machine. This cam receives its motion through worm-gearings and a belt connecting with a countershaft. The work-table may also be operated by a handwheel, as when setting up or adjusting the machine; then the automatic driving clutch is thrown out of mesh by a lever. The indexing of the work is entirely automatic, the motion being obtained from the same cam-shaft that operates the table. When a hob is being ground it is flooded with the cooling lubricant. The lower part of the machine contains a tank from which the lubricant is pumped into a close fitting wheel guard over the wheel. The work-table is pan-shaped and has a drain emptying into the reservoir. The indexing mechanism is covered by a guard which protects it from the lubricant.

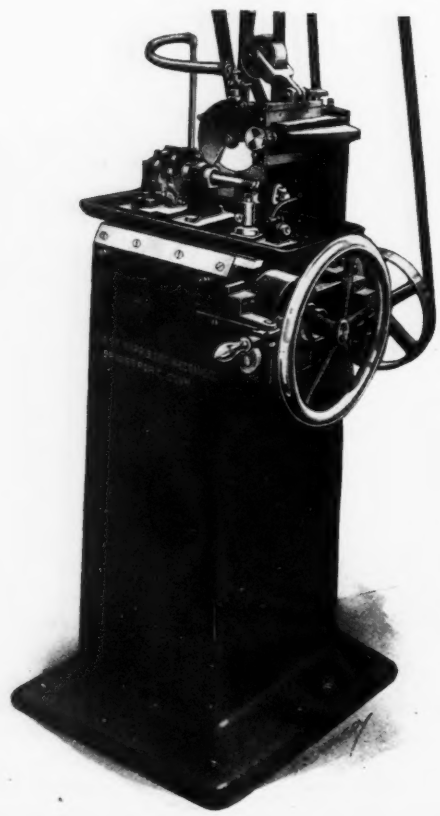


Fig. 1. Front View of Harris Automatic Hob Grinding Machine

Fig. 2. Rear View of Harris Hob Grinding Machine

The tension of the belt is controlled by the idler pulley shown, which operates against the slack side. A setting block is provided for locating the hob to be ground in the proper position. This block may be lowered out of the way after using it. The work is supported at its outer end by a center carried by a swinging arm, which can be clamped rigidly. Surfaces of the machine liable to wear are adjustable and carefully protected from abrasive. The machine also has ample facilities for lubricating the moving parts.

METALWOOD HYDRO-MECHANICAL RIM SHRINKER

The Metalwood Mfg. Co., Leib and Wight Sts., Detroit, Mich., is now manufacturing a hydro-mechanical rim shrinker or banding press for automobile wheel rims. This press is operated by hydraulic pressure. The motion is transmitted to the dies, which force the rim inward, by means of a powerful toggle mechanism. The front view, Fig. 1, shows the arrangement of the eight dies, and the side view, Fig. 2, illustrates the general construction of the press. The closing of the dies is regulated by the handwheel shown in the illustration, which, through worm-gearing, controls the position of a nut and a screw bolt, which bears against the stop-plate or main casting of the frame. The variation of sizes is taken care of by adjusting this screw bolt forward, which increases the diameter of the ram. A receding movement of the screw bolt allows the cylinder ram a longer travel and a greater movement of the toggles which operate the dies.

Any lost motion in the toggles is compensated for by compression springs. The toggles are adjustable for angularity by means of outside adjusting screws, which may be seen in

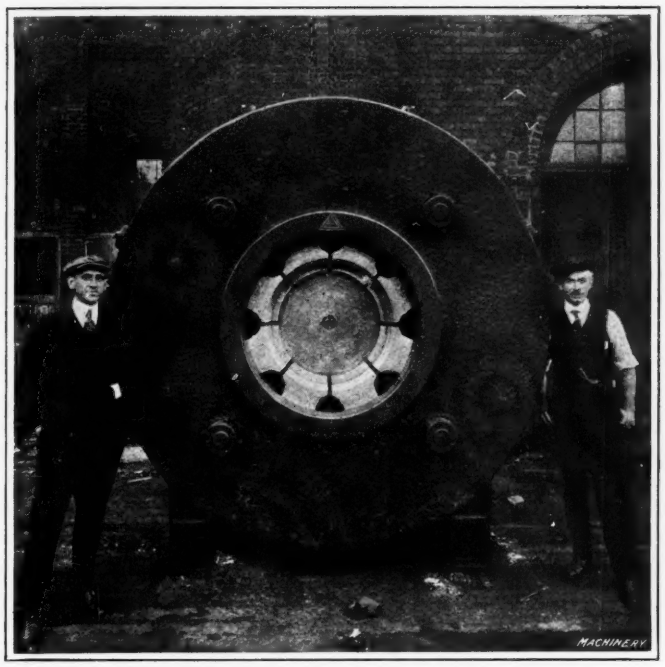


Fig. 1. Front View of Metalwood Hydro-mechanical Rim Shrinker

Fig. 2. All parts of the toggles are of carbon steel and the entire press is made of steel, no cast iron being used, except for the press legs. The ram is of hard semi-steel, finished and polished. The ram shoe or part carrying the pivots or connections to the toggles has babbitted bearings on the columns. The press has a hydraulic pull-back subjected to a constant pressure from an accumulator line. U-type chrome leather packing is used for the ram and also in the pull-back cylinder. The construction is such that the gland may readily be removed from the ram cylinder when new packing is to be inserted.

The machine is designed to operate under a hydraulic pressure varying from 1000 to 2000 pounds per square inch, and at a pressure of 1000 pounds it develops about 675 tons on the toggles or rims to be pressed. An increase of pressure causes the pressure on the toggles or dies used in forming the rims to increase at the same ratio. The dies are of carbon steel and are fitted with angular tongues and grooves, and held in place by screws in the die-block. The press has a maximum closure of 3 inches, and under test has made from eight to nine strokes per minute. The weight of the press is 26,000 pounds.

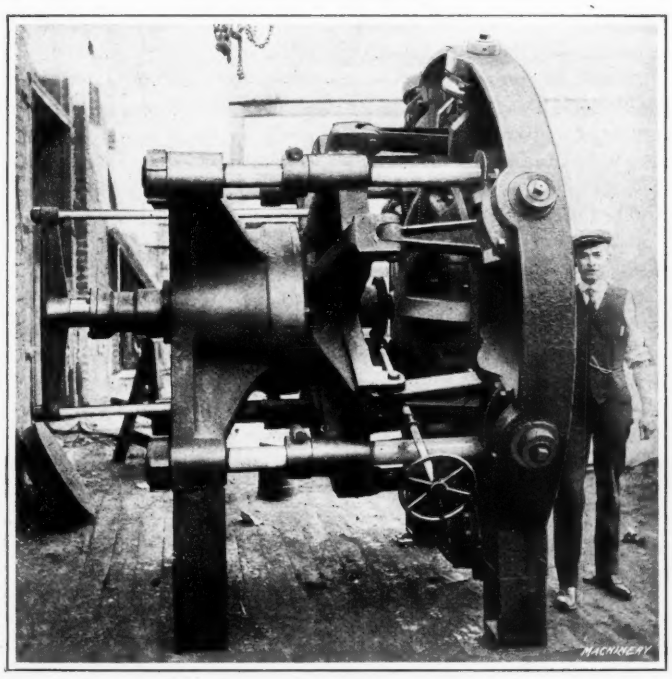
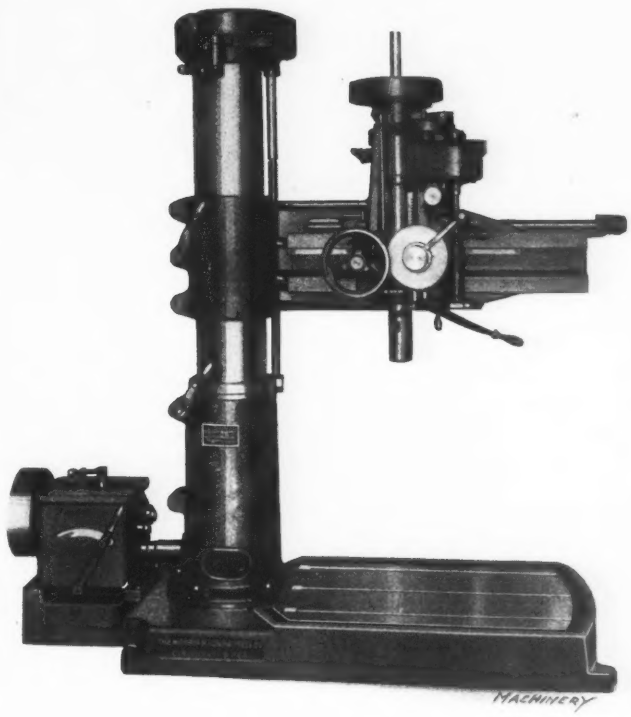


Fig. 2. Side View of Rim Shrinker

MORRIS MACHINE TOOL CO.'S RADIAL DRILLING MACHINE

The Morris Machine Tool Co., Cincinnati, Ohio, is now manufacturing the radial drilling machine shown in the accompanying illustration. This machine has incorporated in its design the various features essential to a modern tool of this type. It is adapted for tapping, facing, counterboring, etc. as well as for high-speed drilling operations. These drilling machines are made in 2½-, 3-, and 3½-foot sizes, capable of drilling to the centers of circles 5 feet, 6 feet, and 7 feet in diameter, respectively. The columns of these machines swivel on roller bearings in a heavily designed stump which is securely bolted and doweled to the base. The column projects deeply enough into the stump to insure alignment under heavy strain, and the stump is arranged to take up any wear in the column bearings.



Morris Radial Drilling Machine

The deep well ribbed base has large T-slots and an oil channel extending around it provided with a screen through which the lubricant passes into the large reservoir. This reservoir has an overflow partition to prevent chips and dirt from entering the pump. The arm is raised and lowered on the column by means of a screw operated by tumbler gears on the cap. These gears are engaged by a handle within convenient reach of the operator, and are so arranged that the tendency is to disengage, thus making it necessary for the operator to hold the elevating handle while the arm is in motion. If the operator should forget to unclamp the arm, or if the latter should reach the extreme position, the gears would disengage, as the operator could not hold them in mesh.

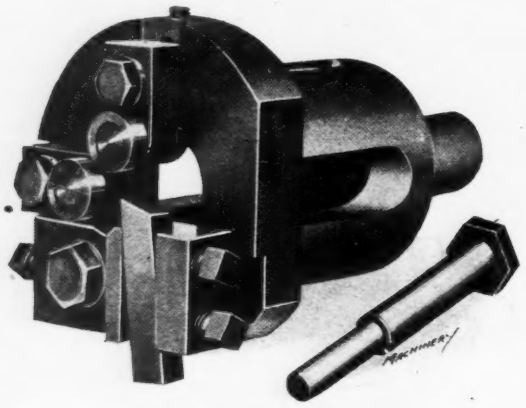
The head is adjusted along the arm by means of a rack and pinion and a handwheel located at the left-hand side. The back-gears may be engaged or disengaged while the machine is running by the lever seen to the left of the spindle. The reversing lever is located on the right-hand side of the spindle below the arm. The reversing frictions are adjustable for wear and the clutches are heat-treated and hardened. All of the gears are covered to protect the operator.

The thrust of the spindle is taken by a ball bearing. The spindle sleeve is graduated and a direct-reading depth gage and automatic feed trip are provided. Ten spindle speeds are available with the cone drive and twelve with the speed-box drive. The feed-box is a unit mounted on the head and gives four changes; each feed change is marked in thousandths of an inch advance per revolution of the spindle. Motor drives

may be arranged either with a four to one variable-speed motor or a constant-speed motor used in connection with a geared speed-box.

WATSON TANGENT-CUT BOX-TOOL

The Biggs-Watterson Co., 722 Guardian Bldg., Cleveland, Ohio, has placed on the market an all-steel tangent-cut box-tool for use on screw machines and turret lathes. This tool is designed to take heavy cuts and still produce accurate work. The tool body is a one-piece steel forging heat-treated to prevent it from becoming battered as the result of careless handling. The rollers and stops are of tool steel hardened and ground. The position of the cutter insures the correct clearance and pressure angle of cut regardless of the diameter. The grinding and replacing of the tool or cutter does not change the cutting diameter appreciably. Standard sizes of cutters are used so that they may be replaced readily when necessary. The tool can be furnished in either right- or left-hand models to fit various makes of hand-operated and automatic machines.



Watson Tangent-cut Box-tool

DRAKE LOCK-NUT

The Western Screw & Lock-nut Co., 342 Mills Bldg., San Francisco, Cal., has placed on the market a lock-nut which is claimed to be efficient in load-carrying strength, correct in mechanical principle and able to withstand the most severe vibrations without jarring loose. Fig. 1 shows the two parts which compose the nut and their relative position when placed together. The arrangement of this lock-nut is further illustrated by the sectional view, Fig. 2, which shows it applied to a bolt.

The lower or main part of the nut is slotted, as clearly shown in the middle view in Fig. 1, to provide a slight amount of elasticity or compressibility. The beveled edges of these fingers engage a beveled seat on the locking part of the nut, as indicated by the sectional views. When the locking member is screwed on, it is claimed that the nut is locked so effectively that no vibrations yet tried in a test have been able to loosen it. In one test, the lock-nut withstood the vibrations from an air hammer delivering a 25-pound blow at 500 blows a minute for nine hours, which was sufficient to jar off an ordinary nut in a comparative test. In another test a ⅜-inch nut withstood the constant jarring from a small electrical apparatus for seventy-two hours without becoming loose.

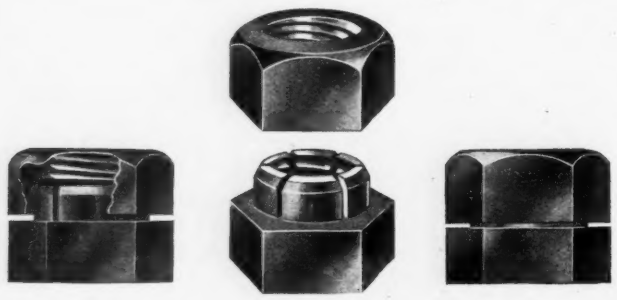


Fig. 1. Drake Lock-nut

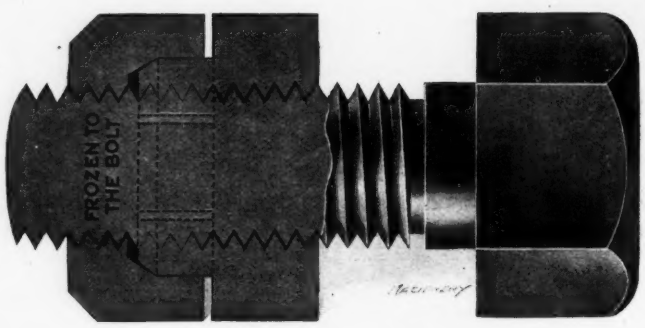


Fig. 2. Drake Lock-nut applied to a Bolt

The complete nut when locked together as shown to the right in Fig. 1, presents a finished appearance and is of standard hexagonal form so that ordinary wrenches may be used. One of the important points claimed for this nut is the fact that the "dead member" is locked and not the moving member. This dead member which bears against the work is designed to have sufficient strength to carry the load and the strength is considerably increased when the locking member is placed in position.

"NAMCO" COLLAPSING TAP

A collapsing tap having several improvements in design which adapt it for an exceptionally wide range of work is shown in Fig. 1 and also in the sectional view Fig. 2. This tap is made by the National-Acme Mfg. Co., Cleveland, Ohio. The tap body and shank are no larger than the cutting diameter of the chasers. As the maximum diameter represents the extreme cutting size of the tap, there is practically no limit to the depth to which work can be tapped, since it is only necessary to increase the length of the shank according to the depth required; therefore, it is possible to use the design of tap here illustrated for cutting threads to depths which exceed the length of the chasers many times, and on classes of work for which taps having a relatively large body or shank could not be used.

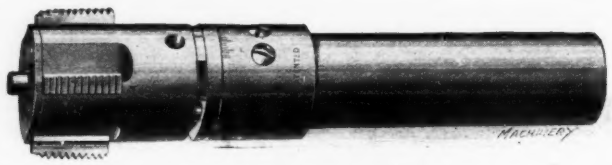


Fig. 1. "Namco" Collapsing Tap

These collapsing taps are designed for use on all turret head machines, screw machines, bolt threaders, finishing lathes, or wherever threads one inch or larger in diameter need to be tapped. They may also be used for either straight threads or pipe threads. The chasers are supported throughout practically the entire length when cutting, and either right- or left-hand threads can be cut by using the proper chasers.

The operation of the tap is as follows: When the travel of the turret is stopped at a predetermined point, the tap continues to cut until, at the required depth, the forward move-

SIZES AND CAPACITIES OF "NAMCO" COLLAPSING TAPS

No. of Tap	Outside Diameter, Inches	Capacity, Min. — Max.	No. of Tap	Outside Diameter, Inches	Capacity, Min. — Max.
118	¾	1 — 1⅛	334	2½	3 — 3¾
138	⅞	1¼ — 1⅜	414	3	3½ — 4¼
158	1	1⅜ — 1⅝	434	3½	4 — 4¾
178	1¼	1⅝ — 1⅞	514	4	4½ — 5¼
214	1½	1⅞ — 2¼	534	4½	5 — 5¾
234	1¾	2¼ — 2¾	614	5	5½ — 6¼
314	2	2½ — 3¼	...	...	.....

Machinery

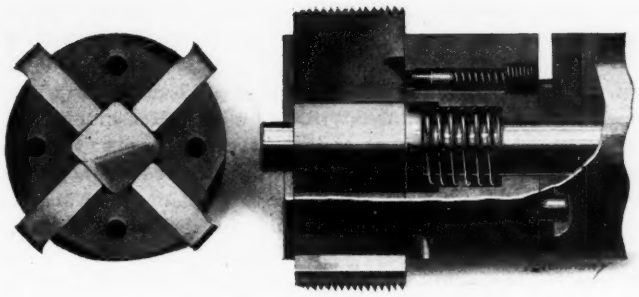


Fig. 2. Sectional View of Collapsing Tap

ment due to the action of the chasers in the tapped hole causes the driving pins to disengage; the chasers then revolve with the work until the tripping point is reached, when they collapse and are automatically released from the tapped hole. The end views, Fig. 3, illustrate the positions of the chasers for cutting right- and left-hand threads and also the change which takes place when the chasers move inward and the tap is in the collapsed position. The view in the lower right-hand corner shows the tap set for the smallest adjustment. When a tap is used on a drilling or chucking machine and the depth of the hole is measured from the outer face or surface, what is known as an outside trip is provided. The use of this trip insures collapsing the tap at a given depth from the surface, thus insuring uniformity and protecting the tool itself. When this collapsing tap is used on the Acme and Gridley single- and multiple-spindle automatics and 2-A bolt threaders, a spool

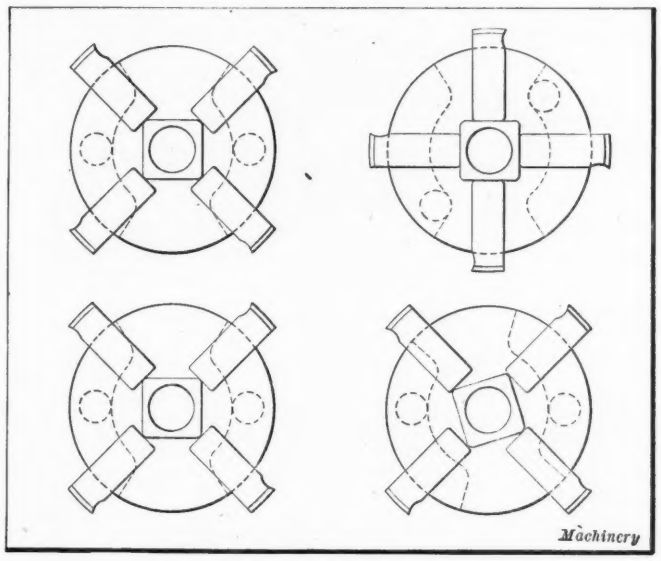


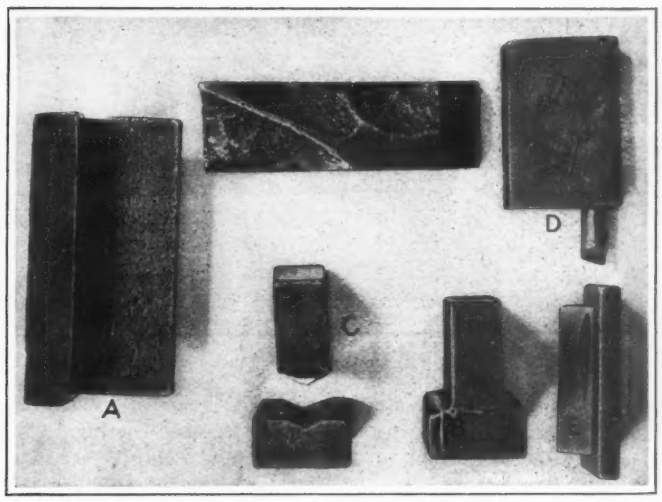
Fig. 3. End Views of Collapsing Tap

and tap operating mechanism is applied. The sizes, with the minimum and maximum capacities of these collapsing taps, are given in the accompanying table.

FERRO BRAZING PASTE

The Ferro Brazing Paste Co., 1423 Farragut Ave., Chicago, Ill., is now manufacturing a paste which makes it possible to braze all metals except soft brass and aluminum. An idea of the range of work that may be handled can be obtained from the fact that it is possible to braze copper onto malleable iron, cast iron, steel, etc. Stellite may be brazed onto cold-rolled steel bars; and high-speed and carbon tool steels may be brazed onto cold-rolled steel bars. These applications are of particular value in making tools, as it is possible to effect a considerable saving in the cost of high-priced steels. In addition to the uses already mentioned, cast iron may be brazed onto cast iron, and there are a number of other metal combinations that may be handled with equally satisfactory results.

Ferro brazing paste is a chemical that comes in the form of a grease and is rubbed on those surfaces of the work that are to be jointed together. The work is then heated in a gas furnace, and it is believed that the chemical has a tendency to open the pores of the metal, thus making it possible to secure a partial weld in addition to brazing the joint through the use of ordinary brazing spelter consisting of one-third zinc and two-thirds brass. This method of brazing may be used to advantage in making repairs or in the manufacture of tools and many other metal products. In the accompanying illustration, the piece shown at *A* consists of copper brazed onto cast iron. At *B* and *C* are shown two pieces of cast iron brazed together, and in this case the joint was so perfect that a test showed that the metal broke before the brazed joint could be torn apart. The possibility of brazing high-speed



(A) Copper brazed to Cast Iron; (B) and (C) Cast Iron brazed to Cast Iron; (D) and (E) High-speed Steel brazed to Cast Iron

or carbon tool steel to cast iron is illustrated at *D* and *E*, where it will be seen that a perfectly smooth and uniform junction is secured, and this is of sufficient strength to enable tools to stand up under severe conditions of service.

HOLMES MACHINE VISE

The Holmes Mfg. Co., Shelton, Conn., has placed on the market the vise shown in Figs. 1 and 2. This vise is the result of a study of the requirements of large munitions plants where production milling and other operations requiring a good machine vise have been in progress. It is of heavy construction, and there is no tendency for the movable jaw to lift and throw the work out of true. The cutting strains are taken on the solid jaw, while the movable jaw has a floating movement, as described later.

The solid or fixed jaw *A* is bolted to the main body of the vise base. The main casting is centrally slotted to receive the sliding jaw *B*. It will be noticed that jaw *B* has a base that extends the full length of the vise, and has the clamping section at one end and the portion that receives the operating screw at the other end. Jaw *B* is prevented from lifting by its close fit in the slotted base and is held down by the application of jaw *A* at one end and of guide strip *C* at the opposite end. If wear should develop at any time, it is only necessary to remove the solid jaw *A* and the guide strip *C*, take a light planer cut over the base of the casting, and reset the jaw and guide strip to make the sliding strip of jaw *B* more accurate. Both jaw castings are made of semi-steel.

The floating feature of the movable jaw is secured by pivot-

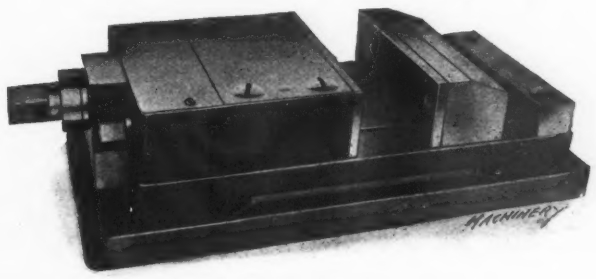


Fig. 1. Holmes Machine Vise

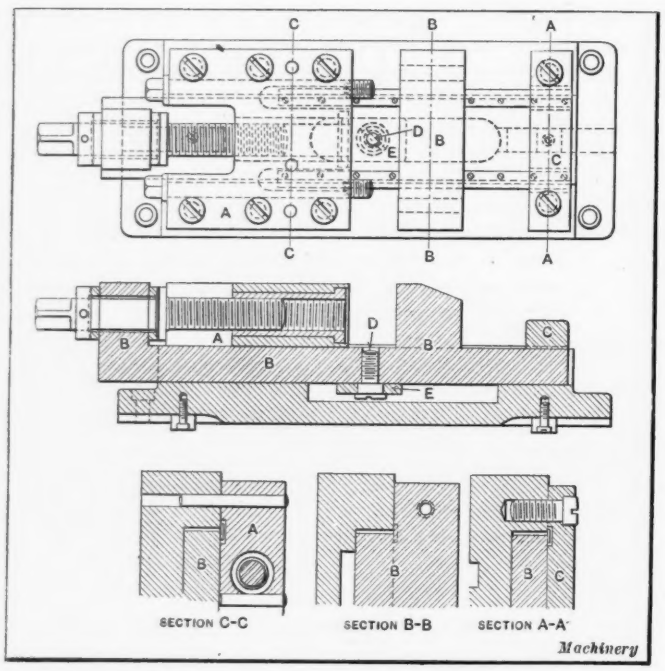


Fig. 2. Sectional Views and Plan of Holmes Machine Vise

ing this member upon stud *D* that is supported by sliding block *E* operating in a milled slot in the base casting. The hole in the left-hand end of the sliding jaw *B* that is bored to receive the operating screw is made large enough to allow the necessary movement at this point. The operating screw is 8 pitch and the buttress type of thread is employed. The steel screw works in a brass bushing, and a protecting cap at the end keeps dirt and chips from the threaded hole. The movable jaw has a travel of three inches. The slot in the main casting in which block *E* operates is filled with oil, and thus provides permanent lubrication for this feature.

Vise jaw faces or "false jaws," as required, are attached to the faces of the jaw castings by screws. The vise itself may be clamped to the table of the milling machine or other machine tool by four screws at the corners, or, if desired, it may be strapped on, the clamps or straps engaging slots, one of which may be seen at the side. The weight of the vise is 48 pounds.

BROWN & SHARPE MICROMETER INDEX

An attachment for the spiral head and universal index centers known as a micrometer index has recently been perfected by the Brown & Sharpe Mfg. Co., Providence, R. I. This attachment is intended for indexing, with greater facility, irregular spacings in degrees and minutes, and it gives results much finer than are ordinarily obtained with the regular equipment. Heretofore, such indexing was obtainable only by a rather complicated process, involving the careful consideration of index plates and calculations of differences by which errors were easily possible. With the micrometer index these calculations are eliminated and a direct reading is secured. The relatively finer divisions that can be indexed are apparent from the fact that by the usual method of using one hole in the forty-nine-hole circle (that being the largest plate regularly furnished for B. & S. heads) the smallest division obtainable is 11.02 minutes, whereas the micrometer index readily gives readings to ½ minute.

The attachment, as shown in Fig. 1 and also in the diagram Fig. 2, consists of a compact housing containing a worm on a vertical shaft, at the upper end of which a dial, graduated to half minutes, is located. This worm meshes with a wheel mounted free on the spiral head worm-shaft. The regular index plates are fastened directly to this worm-wheel, and connection with the spiral head worm-shaft is obtained by the regular index crank and pin engaging with holes in the index plate. One revolution of the index crank rotates the spindle 9 degrees, by means of the 40 to 1 reduction. By giving the vertical shaft of the attachment one revolution, this 9-degree movement is divided into quarter degrees by a 36 to 1 reduction. The graduated dial on the worm-shaft has thirty divisions; consequently, a movement of one graduation turns the spindle of the spiral head ½ minute, and indexing to this reading is therefore obtained directly.

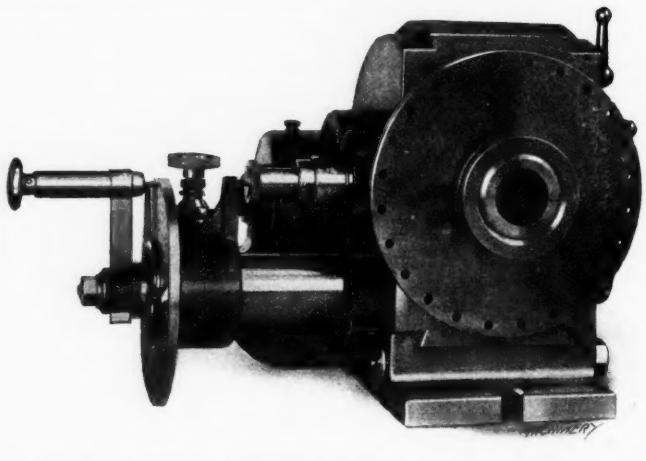


Fig. 1. Brown & Sharpe Micrometer Index for spacing in Degrees and Minutes

The micrometer index is easily attached, and it does not hinder the spiral head in the regular performance of its work. When in use the index-plate stop-pin engages a hole in the attachment casting and prevents it from rotating. When it is not desired to use the micrometer index, as when cutting

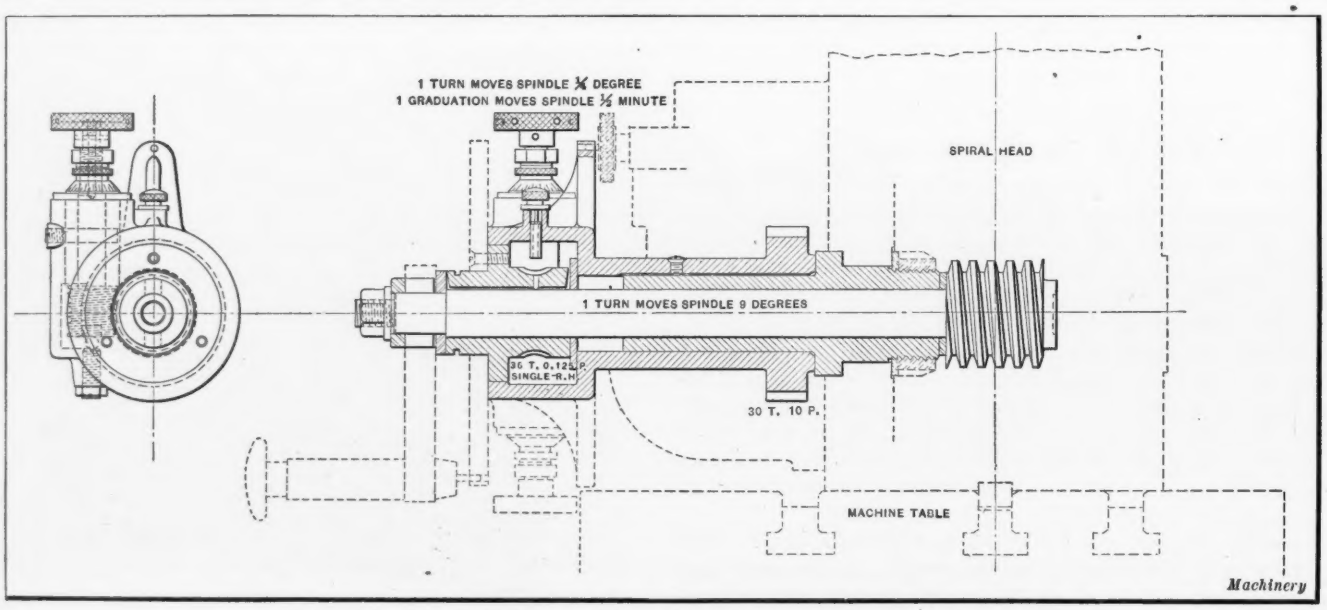

1 TURN MOVES SPINDLE ¼ DEGREE
1 GRADUATION MOVES SPINDLE ½ MINUTE
SPIRAL HEAD
1 TURN MOVES SPINDLE 9 DEGREES
36 T. 0.125 P. SINGLE-R.H.
30 T. 10 P.
MACHINE TABLE
Machinery

Fig. 2. Sectional View of Micrometer Index which gives Direct Readings to One-half Minute

spirals or for differential indexing, the stop-pin is withdrawn and the operation carried on in the usual manner. In applying the attachment, the regular worm-shaft, eccentric sleeve and gear are removed and replaced with a new worm-shaft and sleeve furnished with the attachment. The remainder of the mechanism is then slipped in place over the worm-shaft eccentric sleeve, the regular plates, sectors and crank being used, and held in place in the usual way.

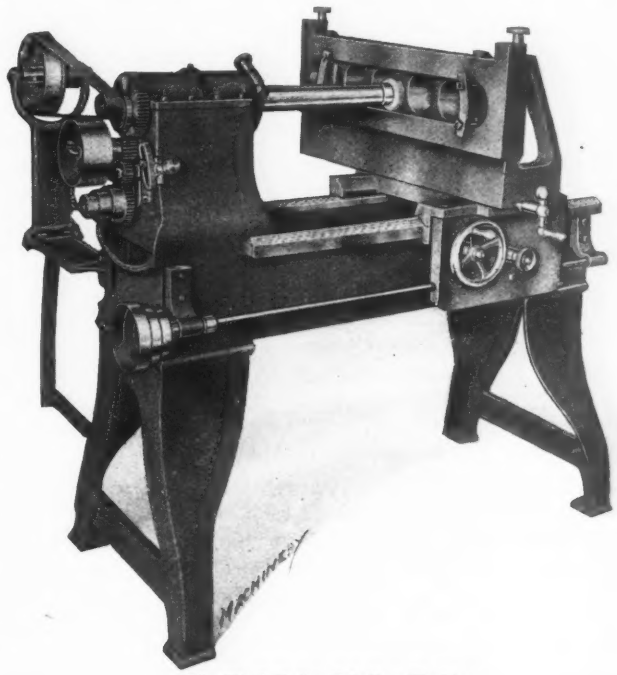
NEWTON FOUR-SPINDLE BORING MACHINE

A new design of four-spindle street railway and mine locomotive boring machine has been developed by the Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa. Earlier types of this machine have been extensively used for boring the axle, armature shaft and field bearings of motors for street railway equipment and mine locomotives. The machine illustrated was originally designed for boring the axle and end bearings, as well as the field pads of steel railway motor castings. Various other machines have been built according to the same general plan, but with slight modifications, such as the inclusion or omission of back-gears in the drive of the main end-bearing boring spindles, a rapid traverse for the spindle saddles, geared feed-boxes, hollow or solid spindle noses, auxiliary boring spindles inside the sleeves, and changes in the location of operating levers according to individual requirements.

Machines of this type have spindles or sleeves with exterior threads on the nose for carrying cutter-heads or boring-bars, and each spindle has an independent worm and worm-wheel drive controlled by a clutch. The main spindles remain in fixed positions in their saddles, and their alignment coincides, although in special cases spindles have been equipped with a large sleeve having a threaded nose for carrying the boring heads and arranged with drift key slots for locating the spindles at different distances or positions, as determined by the location of the field pads to be bored. In such cases, boring-bars are screwed onto the nose of one spindle and the other one is bored hollow and bushed to serve as a support for the outer end of the boring-bar. The spindles used for boring the axle bearings are in the same vertical plane, but their saddles and rear driving gear brackets are adjustable crosswise to give the various center-to-center distances required within the range of the machine. These machines are preferably arranged for one driving motor on each end of the two adjacent spindles, but they can be equipped for a belt drive or with a separate motor for each spindle. Provision is made for the use of spacing blocks to facilitate the accurate duplication of center distances.

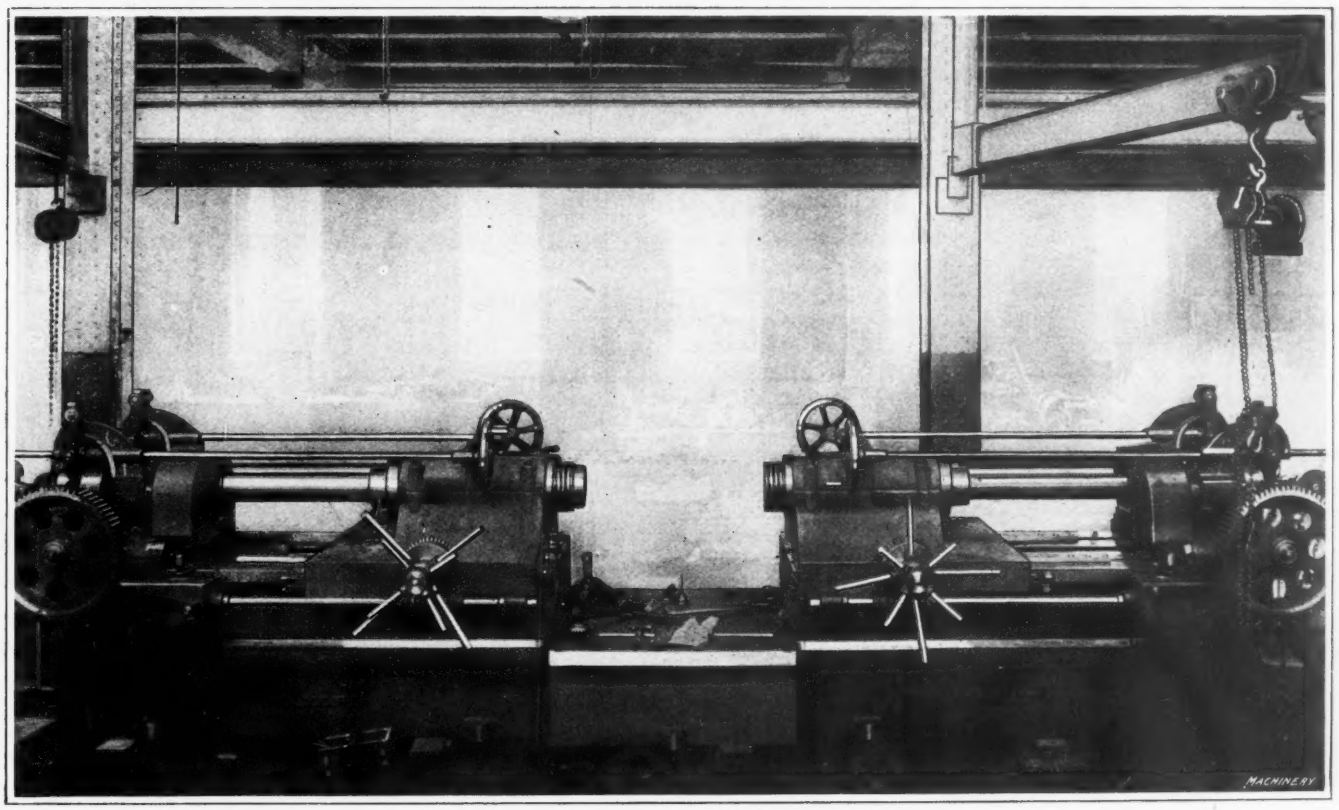
SCHMIDT CYLINDER GRINDING MACHINE

The B. L. Schmidt Co. of Davenport, Iowa, has brought out a cylinder grinding machine designed especially for use



Schmidt Cylinder Grinding Machine

in repair shops, garages, etc., for regrinding cylinder bores. This machine may be used for various classes of heavy grinding operations within its range. The bed is of box section, and it has a large V-shaped bearing at the front and a flat bearing at the rear. The headstock has been made strong and rigid and has large spindle bearings for avoiding vibration



Newton Four-spindle Boring Machine

and producing smooth surfaces such as are required in automobile cylinders. The carriage is gibbed front and back and has a bearing on the bed throughout its entire length. The cross-slide of the carriage has a bearing surface 22 inches long by 8 inches wide, giving the angle-plate a rigid support. The carriage is reversed by a pair of tumbler gears working from the gear on the driving pulley. The feed-rod has a three-step cone, thus providing three changes of feed to the carriage.

The angle-plate has a separate front plate equipped with two knurled knobs for raising and lowering it. This adjustment facilitates centering the cylinder on the angle-plate. This angle-plate will hold all cylinders from the smallest of the motorcycle type up to a solid block of six cylinders 31½ inches long. Separate plates can be furnished having smaller or larger openings. The angle-plate has a long slot in the slide for clamping the cross-feed screw nut. This nut can be loosened and the angle-plate pulled to any position on the carriage and then clamped; the finer adjustments are made with the cross-feed screw. The countershaft attached to the machine bed, and also the grinding wheel arbor, are equipped with ball bearings. The length of the bed is 55 inches, and the width, 15½ inches. The machine will grind cylinders from 2½ to 8 inches in diameter and 15 inches long. The height from the bed to the center of the spindle is 12 inches, and the floor space required, 5 by 3 feet.

BAKER HIGH-DUTY MANUFACTURING DRILLING MACHINE

Baker Bros., Toledo, Ohio, have recently added to their line of heavy vertical drilling machines a machine known as a No. 216 single-purpose high-speed drilling machine. This machine, which is shown in Fig. 1, has capacity to drive 1½-inch high-speed drills to the limit of their efficiency in steel. It is designed especially for quantity production, but is adapted for a wide range of work.

Speeds are secured by change-gears. In this manner practically any speed between 76 R. P. M. and 614 R. P. M. may be secured. By changing top driving gears, a speed range from 25 R. P. M. to 614 R. P. M. may be obtained, with a possibility of securing 105 speed changes. The speed gears can be readily and quickly changed. The change-gears are well guarded by a neatly designed box cover which can be readily removed.

The feeds are also secured by change-gears. A quick change from a drilling feed to a reaming feed is available, thus securing feeds 3 1/3 times the drilling feeds. This change is made by a push-rod at the left of the spindle. On the standard machine a drilling feed range of from 0.005 to 0.024 inch and a reaming feed range of from 0.020 to 0.089 inch can be secured. Change-gears for securing six feeds are furnished as standard equipment with the machine. Gearing for additional feeds can be furnished as special equipment. The feed changes are made at the left-hand side of the machine within easy reach of the operator.

All operating levers are conveniently located. The machine is started and stopped by shifting a belt on tight and loose pulleys. A spring device holds the belt securely on or off. In the off position a brake is applied in such a manner as to stop the spindle quickly and hold it effectually.

The spindle is of forged high-carbon steel and is fitted with special chrome thrust races. The spindle nose is bored for a No. 5 Morse taper, and is slotted across the end for driving heavy boring and facing tools. The spindle sleeve has a bearing in the head for its entire length. This is a novel feature and adds greatly to the durability and rigidity. The feed pinion and rack are hardened nickel steel. The worm-gear is provided with a safety shear pin to protect the feeding mechanism and provide for uniform wear.

Fig. 2 shows how these machines can be arranged in gangs. This particular view illustrates the compact arrangement of a four-spindle unit and the small floor space required. Machines are furnished as one-, two-, three- or four-spindle units. Each machine in a gang is a single, belt-driven, self-contained unit, complete in itself. Gang machines can be furnished with one continuous table or with independent tables for each spindle. The table is raised and lowered by means of elevating screws and is designed with ample pockets for cutting lubricants. It is so constructed that it can be bushed readily for supporting the boring-bars.

The distance from center of spindle to face of column is 10 inches; maximum distance from end of spindle to table, 32 inches; length of feed, 12 inches; vertical adjustment of table, 18 inches. The driving pulleys are 15 inches in diameter and 2½ inches wide. A four-spindle gang drilling machine takes up a floor space of 8 feet, 5 inches by 3 feet, 10 inches, and weighs about 10,250 pounds. A single-spindle machine requires a floor space of 2 feet, 5 inches by 3 feet, 10 inches, and weighs about 2550 pounds.

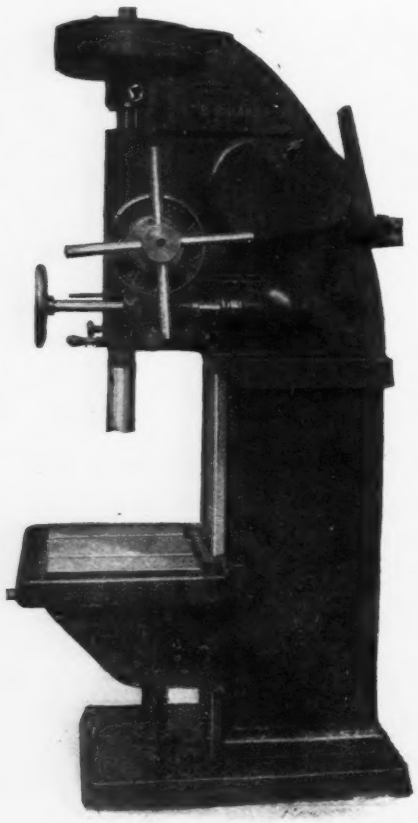


Fig. 1. Baker High-duty Drilling Machine

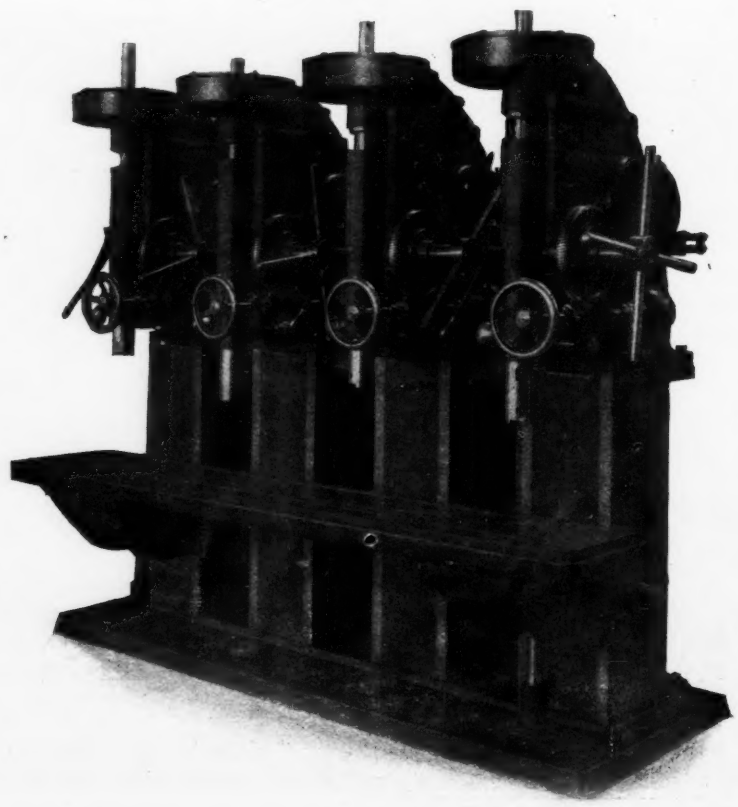


Fig. 2. Four Machines of Design shown in Fig. 1 arranged in a Compact Gang

NEW MACHINERY AND TOOLS NOTES

Return Mechanism: B. Menkin, 2141 Honeywell Ave., New York City. A return mechanism for the knockout of a die, consisting of a helical spring which is wound about the exterior of the die and engages a cross-bar and fixed pins in such a manner as to provide a return movement for the knockout. The application of this spring is not limited to dies.

Air-operated Vise: Hannifin Mfg. Co., Chicago, Ill. A vise designed especially for assembling work, though it may also be used on drilling and milling machines. The vise is closed instantaneously by the application of air. False jaws, similar to those used in a chuck, or plain, hardened steel jaws may be used. The capacity of the vise without the jaws is 7 inches, the height of the jaws is 5 inches, and the length overall is 19 inches.

Dead Front Switchboard: General Electric Co., Schenectady, N. Y. In this switchboard all live parts are inaccessible from the front, except the current and potential receptacles, and the live parts of these are recessed so that accidental contact with them is difficult. Grillwork screens prevent anyone except the person holding the key from entering the space at the rear. Disconnecting switches render the inspection and repairing of the circuit breakers easy and rapid.

Turbine-driven Fan: Terry Steam Turbine Co., Hartford, Conn. A turbine-driven fan applicable for boiler-room service. With the general adoption of high-speed reduction gears, it has become possible to utilize turbine drive for induced-draft fans. Many units of this type have been installed on boilers utilizing the heat of the gases from furnaces and cupolas. The turbines in this unit are built by the Terry Steam Turbine Co., but the fans are built by the Green Fuel Economizer Co.

Adjustable Drilling Brace: Adjustable Drill Brace Co., Boston, Mass. Drilling brace, consisting of steel tubing posts, that vary from 24 to 28 inches in length and from 1⅛ to 2⅛ inches in diameter. The post is secured to the base by an angle-plate which permits it to be adjusted to any angle. The arm is clamped to the post in a similar manner and can be swung through a large arc. Teeth on the angle-plate and the post clamp prevent the adjustment being changed by the drilling pressure.

Hacksaw Machine: L. S. Starrett Co., Athol, Mass. The main features of this machine are the treadle for raising the saw frame, saving both time and labor; an oil dashpot control for the descent of the blade, which allows the machine to be started when the frame is up and prevents stripping the saw teeth or breaking the saw; a stroke adjustment so that stock from 1 to 6 inches in diameter may be cut; and a frame locking device. A pump and lubricating tank are located inside the base.

A 20-inch Lathe with Quick-change Gear: Walcott Lathe Co., Jackson, Mich. Thirty-two threads, ranging from 2 to 112 per inch, are provided for by the quick-change gear-box of this lathe; and special, very fine, or coarse threads may be cut by changing one gear at the end of the lathe. Using the tumbler gears and cone only for thread cutting is said to simplify the design of the gear-box. The apron is of the double-wall type, and the gears are steel drop-forgings with wide face and coarse pitch.

Roll-turning Lathe with Enclosed Headstock: Youngstown Foundry & Machine Co., Youngstown, Ohio. A roll-turning lathe with a headstock that is fully enclosed. All the gearing is of steel with cut teeth and may be run in a bath of oil. The headstock cap acts as a support for the motor drive, but it may be removed with the motor, thus exposing all gearing when repairs are necessary. Hand-holes permit easy inspection of the gearing at all times. The lathe is equipped with push-button electric control mounted directly on the machine.

Critical Point Pyrometer: Gibb Instrument Co., Pittsburg, Pa. An instrument known as the "Crit-Point," that determines the critical point in heating steel. It is a well-known fact that steel loses its magnetic properties when it reaches the critical point, and it is on this principle that the "Crit-Point" is based. A magnetic indicator is applied to the steel in the furnace; when the steel has reached its critical point, a needle on the meter moves to a red line indicative of the critical point. This instrument does not measure temperature, but is intended solely to indicate the critical point for use in heat-treating steel.

Screw Press for Testing Punch and Die: Manhattan Machine & Tool Works, Grand Rapids, Mich. A screw press for the use of diemakers in shearing punches into dies. The bed of this press, which is 18 by 36 inches, has fifty-two ⅝-inch holes tapped in its upper surface, so that the die can be mounted in any position. As there is a clearance of 24 inches between the bed and the ram, the die may be blocked up on parallels, and thus provide clearance for springs, cams, etc. It is also possible to line up the punch and die and then raise the ram high enough for the pressure pads, stripper plates, springs, etc., to be mounted without removing the punch from the press.

THE "SIGN SLANGUAGE"

BY J. D. HACKETT [1]

Few large employers know how many of their foremen are still using the "sign slanguage" in communicating with the foreign workman. If they did, they would understand why production is so slow, why accidents occur, and why there are misunderstandings that end in strikes. The foreign workman who doesn't know English can't do very efficient work. He probably doesn't know what he is working at. He may not even know the name of the firm for which he is working. There are about a million men of this kind in the plants of the country today; and though it is not easy to measure efficiency loss, it can be easily shown that language does make a difference; otherwise why should men aspire to speak another language? If the efficiency of the foreigner could be raised 5 per cent, it would be a gain well worth the effort. It is known that difference in language is the cause of many accidents. For instance, in a recent case where two men died from gas, the newspaper report says: "Whether these men had been warned in a language in which they could understand the danger is a question. One could not speak English; the other only slightly." The one word danger in a language they could understand would have saved two lives. Another instance of the kind was where a foreman shouted to the workman to get out of the way; as Steve did not understand, he got a fractured skull. At first sight it might seem right to blame the foreman for this dereliction, but he is less to blame than the employer who allowed this condition to exist.

The type of employe should determine the method of solving this problem. When dealing with skilled workmen, it may be advisable to have a night school with a properly qualified teacher, or it may even be worth while to have classes for the men during working hours. But in the majority of cases the common laborer, illiterate even in his own language, is scarcely a fit subject for extensive instruction from an educational point of view. For these a less ambitious scheme should be adopted, unless the employer is a philanthropist.

The remedy in most cases is to teach the laborer, by means of the foreman, such few words as are necessary for the ordinary transaction of business. It is true that the foreman is not a very promising subject, but he is easier to teach than the workman. It is claimed that uneducated workmen have no more than four hundred words in their vocabulary, and a study of the relation between the workmen and foreman shows that very few words are necessary to cover every situation in the day's work. The employer, however, has shown so little interest in the situation that the foreman must be excused for having achieved the almost incredible feat of not knowing a word of the language spoken by his men, though in daily contact with them for years. This situation will last until the gravity of the present labor shortage forces the employer to make the best use of the material he has.

In order to reach the workman through the foreman, the latter should be provided with a card containing a few phrases phonetically rendered in the language of the workman. These phrases should embrace the ideas of command, warning, approval, and direction, which the foreman should be taught to use frequently. The phrases should be selected carefully and the literal translations of such idioms as "Look out" should be avoided. It is well to keep in mind the predicament of a Frenchman who occupied a lower berth on a particularly stormy voyage. His companion, in the upper berth, on the approach of a paroxysm, shouted "Look out," which command the Frenchman obeyed with disastrous results.

Apart from the facilitation of work which this method will bring, the workmen will be favorably impressed when a foreman attempts to speak even a few words which they understand. In addition, another important result is obtained; the workman in a short time will begin to understand the English equivalent. This method of language teaching may be carried out in the course of the work. It cannot, and should not, be taught in the schoolroom where workmen are not willing to go. An elaborate system is not necessary; the aim should simply be to teach the workmen and foremen to understand each other.

[1] Address: 4711 Cedar Ave., Philadelphia, Pa.

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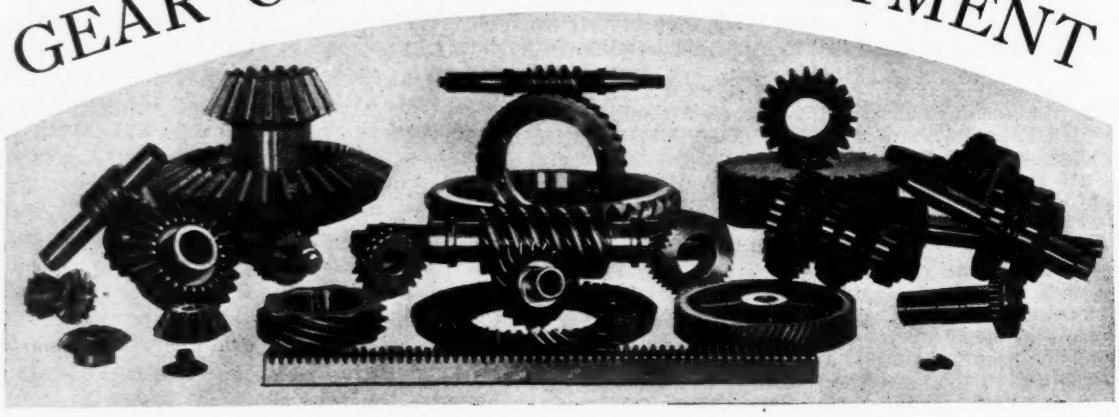
OUR COMPLETELY EQUIPPED GEAR CUTTING DEPARTMENT



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WE can handle more work in this department. There is a large volume going through now but it takes quantities of large orders to tax the several hundred machines to a point where prompt attention cannot be given to all customers.

This finely equipped department is operated by an organization skilled in all details of gear cutting and is prepared to give quick service on all kinds of work. Place your orders for quantities of special gears here and benefit by the experience accumulated during over fifty years of gear cutting practice.

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Spur Gears (to 72 in. diameter). Bevel Gears (to 18 in. diameter).

Circular and Angular Bevel Gears, Worm Gears, Spiral Gears (to 20 in. diameter, 3 pitch in cast iron, 4 pitch in steel, heavy and light type).

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OF EVERY BROWN & SHARPE PRODUCT

FIRST in the mind of every good machinist is a natural pride in the accuracy of the work he produces. With him accuracy must not only be attained, but maintained, so when he purchases the precision tools upon which he depends for accuracy he naturally chooses the most reliable and durable kind he can obtain.

Therein lies the reason why

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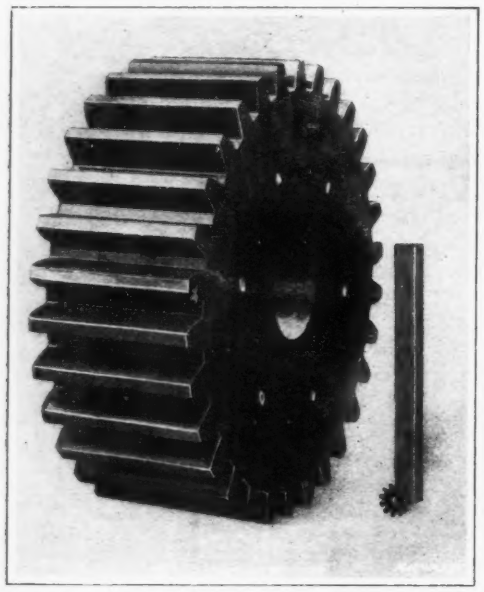
LARGE NOISELESS PINION

The accompanying illustration shows two bakelite "Micarta—D" noiseless gears compared with a foot rule. The larger gear is 21 inches in diameter and has an 8-inch face. It is designed to transmit 100 horsepower at 425 revolutions per minute. A comparison of these gears will indicate the adaptability of this comparatively new material, which has been developed by the Westinghouse Electric & Mfg. Co., E. Pittsburg, Pa., for use in both large and small gears. It may be of interest to note that in making the large gear, no metal shrouds were used or needed. The claims made for these gears are that they are as strong as those made of cast iron, and in addition to being noiseless, are unaffected by atmospheric changes, cannot be destroyed by rats, can be stored indefinitely without deterioration and can be operated in oil without swelling.



Pinions made of Bakelite "Micarta—D," compared with Foot Rule

* * *

BRODERICK CLEANING AND PLATING MACHINE

The Broderick continuous-process cleaning and plating machine not only performs the actual plating process automatically, but cleans, rinses and dips the parts automatically. This machine has been placed on the market by the Munning-Loeb Co., Matawan, N. J. It consists of a series of tanks containing the cleaners, rinsing baths, dips and plating solutions arranged in the proper order and extending a distance of about fifty feet. Above the tanks there is a carrier system, consisting of two endless chains driven through sprockets by a ½-horsepower motor and carrying a series of vertical rods, which hold the parts to be plated. By a simple cam mechanism, each rod is moved forward and raised or lowered at any predetermined point, thereby passing the work through the different baths by raising it over the dividing walls between adjacent tanks and lowering it into the baths in the proper sequence of operations; the work is finally delivered to the starting point completely plated. The movement of work agitates the plating bath, which permits far greater current densities, without danger of burning, than are possible in still tank plating; this feature, together with the elimination of handling the parts, enables the plating to be done rapidly. It is also claimed that a greater uniformity of deposit may be obtained with the Broderick machine, because the time of immersion in the various baths is definitely fixed by the speed of the machine. This speed is adjusted by the plating foreman to give the best results.

The machine, while standardized in its component parts, can be modified to meet any unusual requirements merely by varying the number of standard units in its assembly and the arrangement of tanks and lifting cams. The speed is adjustable over a ratio of as high as 3 to 1, and this variation may be increased if necessary. For ordinary plating conditions it is found that a speed of about two feet per minute is satisfactory. At this speed the work completes the circuit of the tanks in about one hour, this time sufficing for all cleaning baths, rinses and dips, in addition to the actual plating. Where light deposits are desired, the speed may be increased and the time correspondingly reduced, while exceptionally heavy deposits are obtained by a slower speed and a greater time in the baths. The application of the machine in any plating plant is recognized as an individual engineering problem, and a suitable arrangement is offered after thorough investigation of the conditions.

* * *

A so-called Christmas savings fund has been instituted by the Cincinnati Planer Co., the Acme Machine Tool Co. and the Greaves-Klusman Tool Co. of Cincinnati, Ohio. The principle on which this fund is based is that 5 per cent of the total earnings of an employe for every month during which he complies with the conditions are placed at 3 per cent interest to accumulate until the day before Christmas, when a check for this amount is sent to him. In order to be entitled to this bonus, employes must not be absent more than one day in the month without excuse, nor late more than one day in the week without excuse. Under this arrangement, the Cincinnati Planer Co. distributed $12,500, the Acme Machine Tool Co. about $6000, and the Greaves-Klusman Tool Co. about $4000 to their employes at Christmas.

* * *

It is estimated that the potential water power of Canada is 17,000,000 horsepower; of this, only 1,590,500 horsepower has been developed. This power is available at all the present commercial centers, with the exception of some of those in the middle prairies. About 500,000 available horsepower is within seventy miles off Winnipeg; of this, only 60,000 horsepower has been developed. About 48,000 horsepower is within fifty miles of Calgary. The Western Canadian Power Co. is developing 25,000 horsepower at its plant on Slave River, thirty-five miles from Vancouver, but the company can easily obtain 100,000 horsepower when all its sites are fully utilized.

PERSONALS

A. B. Hazzard has taken the position of works manager of the Brown Magnetic Truck Co., Philadelphia, Pa.

Horace N. Trumbull has been appointed advertising manager of the S. K. F. Ball Bearing Co., Hartford, Conn.

Andrew L. Gath, formerly with the Manhattan Machinery Exchange, New York City, is now connected with Young. Corley & Dolan, Inc., 115 Broadway, New York City.

Joseph K. Long, occasional contributor to MACHINERY, has been transferred from Renovo, Pa., to Sunbury, Pa., where he is chief draftsman of the Pennsylvania Railroad shops.

James O. Smith, for ten years associated with the American Emery Wheel Works, Providence, R. I., latterly as vice-president, has resigned and joined the Hampden Corundum Wheel Co., Springfield, Mass., as sales manager.

Arthur V. Farr, who for the last three years has been advertising manager of the S. K. F. Ball Bearing Co., Hartford, Conn., has resigned and taken the position of sales manager of the Hess Steel Corporation, Baltimore, Md.

Newell C. Knight, salesman and advertising expert, has formed an advertising company under the name of the Knight Co. Offices have been rented on the top floor of the Home Insurance Bldg., 127 S. La Salle St., Chicago, Ill.

S. B. Taylor, sales manager of the S. K. F. Ball Bearing Co., Hartford, Conn., has been appointed vice-president, succeeding F. B. Kirkbride, who remains on the board of the company. Mr. Taylor will remain in charge of sales.

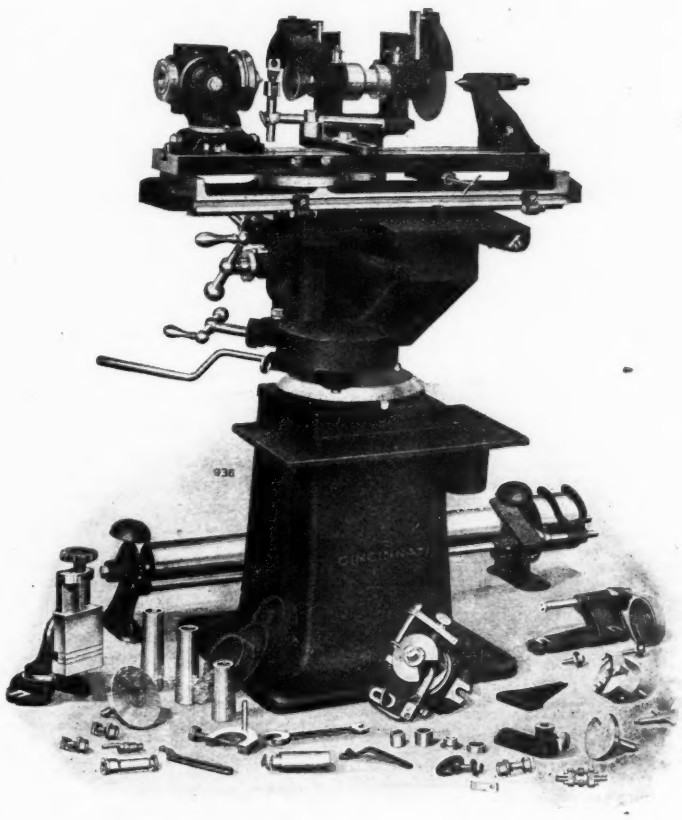
J. G. Waldron, for the past ten years with Wheelock, Lovejoy & Co., New York City, eastern agents for the Firth-Sterling Steel Co., has resigned and taken a position with Hamilton & Hansel' ~ Battery Place, New York City, exporters and importers of Swedish and domestic steel and iron.

G. A. Ungar, former representative of the S. K. F. Ball Bearing Co. in Cleveland, Detroit and Pittsburg, has been appointed technical manager and chief engineer, succeeding Uno Forsberg, who returns to Sweden after completing his work of forming the manufacturing organization of the S. K. F. Ball Bearing Co. in this country.

Herbert Chase, who has been connected with the Automobile Club of America for several years as laboratory engineer and chief engineer, has joined the office staff of the Society of Automobile Engineers, 29 W. 39th St., New York City, as assistant secretary. Mr. Chase was graduated as a mechanical engineer at Sibley College, Cornell University, in 1908.

Read This Quotation:

Then Investigate Your Own Cutter-Sharpening Facilities



"It has long been recognized that proper clearance and rake are of vital importance to cutting tools. Unfortunately, milling cutters which are more sensitive and more easily affected by different clearances have received little attention. It may, therefore, be assumed that the great majority of cutters are improperly sharpened. The user can correct these errors in stock tools by proper sharpening. There are cases on record where a cutter, intelligently sharpened for a particular cut, has increased the output of a milling machine 60%."

Our wide experience in milling has proved the necessity of having exactly the correct clearance on cutters. But cutter grinders were too incomplete to insure reproduction of the right clearance on repeated grindings. We set ourselves the task of solving this difficulty. The 40 per cent, 50 per cent or 60 per cent increased output that proper clearance means was certainly worthy of our best efforts. In the No. 1½ UNIVERSAL CUTTER AND TOOL GRINDER we offer you the result—a simple, correct clearance angle feature.

The machine carries a graduated dial on its headstock spindle from which the clearance angle for all cutters may be read direct.

As a result of obtaining this correct clearance angle the feed may be greatly increased, the cutter cuts as it was designed to; the tendency to chatter is removed—and you get greater efficiency from your millers.

Send for this Bulletin and Get the Whole Truth of the Matter.

CINCINNATI MILLING MACHINE COMPANY

CINCINNATI **OHIO, U. S. A.**

F. E. R. Blomquist, mechanical engineer with the Kelsey Wheel Co., Detroit, Mich., has resigned his position to take up the active management of the Blomquist-Eck Machine Co., Cleveland, Ohio. The business of the Blomquist-Eck Machine Co. has grown so rapidly that more commodious quarters have had to be secured adjoining the present location. Additional machinery has been installed and the organization has been increased substantially. This has made it necessary for Mr. Blomquist to devote his entire time to the business of the Blomquist-Eck Machine Co.

COMING EVENTS

January 6-13.—National Automobile Show in Grand Central Palace, New York City.

January 25.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

May 21-22.—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 22-25.—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

SOCIETIES, SCHOOLS AND COLLEGES

Tanners Institute (Pratt Institute), Brooklyn, N. Y. Fifth annual report of Tanners Institute for the year 1915-1916.

Massachusetts Institute of Technology, Boston, Mass. Catalogue, December, 1916, of the officers and students, with a statement of the requirements for admission and a description of the courses of instruction.

Stevens Institute of Technology, Hoboken, N. J., dedicated the new William Hall Walker gymnasium November 18. The building, which was erected at a cost of $125,000, is elliptical in shape and is, as far as known, the first of this form to be built. It contains a ten-lap track, a large drill court, and the regulation college pool.

University of Illinois, Urbana, Ill., maintains fourteen Engineering Experiment Station Research Fellowships, in order to extend and strengthen the field of its graduate work in engineering. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments to the fellowships are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements are met, the degree of Master of Science will be conferred. Additional information will be furnished by the director.

NEW BOOKS AND PAMPHLETS

A Study of Oil Engines in Iowa Power Plants. By H. W. Wagner. 157 pages, 6 by 9 inches; illustrated. Published by the Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, as Bulletin 42 of the Engineering Experiment Station.

Sewage Disposal for Village and Rural Homes. By C. S. Nichols. 29 pages, 6 by 9 inches; illustrated. Published by the Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, as Bulletin 41 of the Engineering Experiment Station.

Practical Handling of Iowa Clays with Application of Ceramic Principles. By Homer F. Staley and Milton F. Beecher. 48 pages, 6 by 9 inches. Published by the Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, as Bulletin 43 of the Engineering Experiment Station.

On the Making of Munitions. 55 pages, 7½ by 10 inches. Published by the Munition Boards Publicity Bureau, Municipal School of Technology, Manchester, England.

This is a classified index to the various articles that have appeared in some of the engineering periodicals on the manufacture of munitions since the beginning of the European war. While not complete, it will be most useful to all who are intent on securing references to the many articles that have appeared in the technical press of Great Britain and the United States.

Specifications and Tolerances for Weights and Measures and Weighing and Measuring Devices. 44 pages, 6 by 9 inches. Published by the Department of Commerce, Washington, D. C., as Circular of the Bureau of Standards No. 61.

These specifications were issued in order to obtain the greatest measure of efficiency from weights and measures laws and rules and regulations. Since the first adoption of these specifications and tolerances some additions and amendments have been made as opportunity was offered to study and draft requirements for new types of apparatus. The experience of several years has demonstrated that a set of standard requirements has now been developed which meets the needs of trades throughout the country. The circular will be sent free on request.

Cooperation in American Export Trade. Part I. Summary and report. 387 pages, 6 by 9 inches. **Part II.** Exhibits. 597 pages, 6 by 9 inches. Published by the Federal Trade Commission, Washington, D. C.

This report, made by the Federal Trade Commission in two parts, is the result of the commission's investigation into trade conditions in and with foreign countries, where associations, combinations and other conditions affect the foreign trade in the United States. Part II deals with exhibits, being made up of special reports from U. S. Consuls in various countries, excerpts from public hearings, replies from inquiries, etc. Examples of prices and trade agreements of foreign combinations are also given. The report is comprehensive and may be studied with much profit by American manufacturers generally who are intent on formulating a business policy that will provide for the exigencies likely to follow the close of the European war.

Thomas' Register of American Manufacturers. 3500 pages, 9½ by 12 inches. Published by the Thomas Publishing Co., New York City. Price, $15.

The eighth edition of this mammoth work, which is claimed to be the largest classified reference book is divided into five sections, as follows: Section I, finding list or index; Section II, lists of manufacturers classified according to business; Section III, manufacturers of the United States, arranged alphabetically by names, giving home offices, branches, names of officers, sales managers, purchasing agents, etc.; Section IV, leading trade names, brands, etc.; and Section V, appendix containing lists of banks, boards of trade and other commercial organizations, leading trade papers, leading manufacturers' representatives, etc. The sections are printed on white, yellow, pink and blue paper, thus facilitating reference to them. The classification of manufacturers contains 70,000 headings, and covers all manufactured products. The manufacturers' capital or size rating is included, ranging from $500 to $1,000,000. This feature is valuable when using the list for circularizing or other purposes, as it indicates the approximate size of the concerns.

The Elements of Refrigeration. By Arthur M. Greene, Jr. 472 pages, 6 by 9 inches; 192 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $4 net.

This work was prepared with the idea of bringing together in logical order the necessary data required to design, construct and operate refrigerating apparatus. It is suitable for the use of technical students, engineers and those operating refrigerating apparatus. A feature which makes it well suited for use in technical schools is a set of problems in the last chapter illustrating most of the computations which must be made in refrigerating work. The book deals with early methods of refrigerating, different systems of cold storage, refrigerating costs, air machines, and then takes up the thermodynamics of refrigerating apparatus. The types of machines and apparatus are described. Chapter V deals with heat transfer, insulation and amount of heat, and the following chapter with cold storage. Ice making and other applications of refrigeration, costs of insulation and operating costs are taken up in turn. The book is one that can be recommended to all needing a treatise on refrigeration, dealing with the practical and theoretical sides of the subject.

Advertising by Motion Pictures. By Ernest A. Dench. 255 pages, 5 by 7½ inches. Published by the Standard Publishing Co., Cincinnati, Ohio. Price, $1.50.

This book, by a motion picture expert who has given much attention to the commercial possibilities of motion pictures for advertising, demonstrating machinery, etc., was written for the purpose of emphasizing the value of the motion picture in the advertising and business educational fields. It should appeal to all classes of manufacturers desirous of demonstrating their machines and products through the eyes. It dwells on the advantages of telling an advertising story by motion pictures, and describes some of the film advertising methods used by manufacturers. Salesmanship demonstrations by the film and various aspects of the selling game are taken up, including selling shoes, automobiles, real estate, transportation, etc. The author touches on the entertainment side of the motion picture business, showing how manufacturers may use motion pictures to interest and attract employes. Data are included on the cost of equipment, fitting up theaters, etc., which should interest manufacturers in isolated communities especially where there is a scarcity of other means of entertainment.

Handbook for Machine Designers, Shop Men and Draftsmen. By Frederick A. Halsey. 561 pages, 9 by 12 inches; illustrated. Published by McGraw-Hill Book Co., Inc., New York City. Price, $5 net.

This work, first published in 1913, now appears in the second edition, revised and enlarged. Additional matter appears on thrust bearings, roller bearings, critical speed of shafts, geometrical progression of speeds, spur and herringbone gears, and other gearing subjects, including worm-gears, roller chains, friction clutches, spiral springs of the watch spring type, measurement of tapers, velocity and force relations of link work, relation of Brinell and scleroscope hardness numbers, heat-treatment of steel. New tables have been added including lengths of circular arcs, cutting speeds and revolutions, decimal equivalents of prime number fractions, etc. It is the author's plan to keep the work constantly up to date, and corrections, suggestions and contributions are solicited from users. The author recognizes the fact that it is impossible to keep a work of this kind abreast of the times without giving it constant revision and securing the cooperation of mechanical engineers, designers and others having use for the varied mechanical data that it contains.

NEW CATALOGUES AND CIRCULARS

American Blower Co., Detroit, Mich. Bulletin 13, describing "A B C," Type D and "Cyclone" disk ventilating fans.

Charles Stecher Co., 1574 Crossing St., Chicago, Ill. Catalogue of parts for hand screw machines of the plain head and friction head types.

Rochester Ball Bearing Co., Inc., 203 State St., Rochester, N. Y. Bulletin 10, comprising a descriptive price list of Rochester ball thrust bearings.

C. M. Conradson, Eau Claire, Wis. Circular of the Conradson No. 3 duplex helical drive, plain milling machine with longitudinal feed in either direction and both cross and vertical feed.

Stow Mfg. Co., Binghamton, N. Y. Miniature of bulletin 102, reproduced in small size for quick reference. This bulletin treats of Stow flexible shafts and their application to various tools.

Pennsylvania Railroad, Philadelphia, Pa. Safety calendar for 1917, for use in schools to impress on the minds of children the danger of crossing railroad tracks at unguarded "short-cuts."

Athol Machine Co., Athol, Mass. Catalogue 32, illustrating and giving dimensions, prices, etc., of Athol vises, display stands, taper attachments, pipe grips, wrenches, grindstones, countershafts, bench grinders, etc.

Cincinnati Automatic Machine Co., Cincinnati, Ohio. Catalogue of Hayden ¾- by 3-inch five-spindle automatic screw machines, containing information as to equipment, capacity, speeds, control, drive, etc.

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. Bulletin 129, illustrating Chicago hose, hose couplings and hose clamp tools. Bulletin E-45, superseding E-40, of "Duntley" direct-current portable electric hoists.

National Tube Co., Frick Bldg., Pittsburg, Pa. Circular illustrating graphically "National" pipe progress in twenty-eight years. It is stated that ninety per cent of the present pipe production of this country is steel pipe.

United Hammer Co., 141 Milk St., Boston, Mass. Circular of the Fairbanks power hammers, Dupont pattern, formerly manufactured by E. & T. Fairbanks & Co. of St. Johnsbury, Vt., and now made by the United Hammer Co.

Eclipse Interchangeable Counterbore Co., Inc., Detroit, Mich. Catalogue illustrating and describing the "Wiard" chuck made in three sizes. The catalogue also gives price lists of Eclipse interchangeable counterbores and holders.

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. Bulletin 34-W illustrating and describing "Giant" low-grade fuel oil engines. Bulletin 263 describing the Boyer railway speed recorder and giving instructions for applying and operating.

Manhattan Machine & Tool Works, Grand Rapids, Mich. Circular descriptive of the Manhattan toolroom screw press for the use of diemakers in shearing punches into dies, etc. The press is made with a large bed and ample clearance between the bed and ram.

McCrosky Reamer Co., Inc., Meadville, Pa. Catalogue 4 entitled "Cost-cutting Machine Shop Tools," giving specifications for McCrosky reamers, "Wizard" quick-change chucks and collets, expanding mandrels, "Wizard" variable-speed and reversing attachment, etc.

Midvale Steel Co., Philadelphia, Pa. Catalogue of Midvale high-speed tool steels, giving general information on the properties of high-speed steel, forging, annealing, heat-treatment, grinding, tests, etc. A list of the various grades of Midvale high-speed steel and the work for which each is adapted is included.

Gisholt Machine Co., 1212 E. Washington Ave., Madison, Wis. Circular entitled "How to Save Money on High-speed Steel," illustrating Gisholt tool-holders with inserted high-speed tools. With these tools it is possible to use high-speed steel tools down to the last inch. A table of dimensions and prices is given.

Beaudry & Co., Inc., 141 Milk St., Boston, Mass. Booklet illustrating and describing Beaudry hammers, made in two types—the "Champion" and the "Peerless"—and in sizes from 25 to 500 pounds weight of ram. Motor drive can be easily applied to these hammers, and a number of motor-driven hammers are illustrated.

Morse Chain Co., Ithaca, N. Y. Catalogue 15, covering small power drives, showing illustrations of the construction and action of the Morse silent chain and its application in a number of different industries. The catalogue is profusely illustrated with halftone illustrations of actual installations that indicate the wide range of application of silent chains.

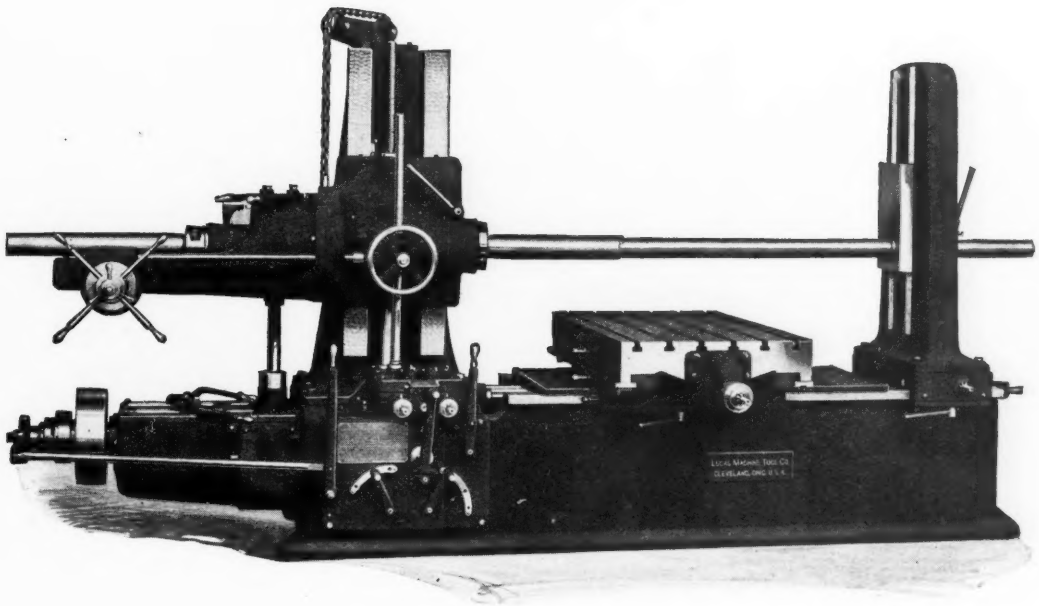
Associated Manufacturers and Merchants, White Bldg., Buffalo, N. Y. Copies of new rules governing so-called dangerous trades that are now being considered by the New York State Industrial Commission. The rules apply to the manufacture of thermometers, mattresses, gloves, industries using

A friend of ours who runs a "contract shop" says that the first question asked him by prospective customers usually is:

"HAVE YOU GOT A LUCAS?"

Meaning the

LUCAS "PRECISION" Boring Drilling and Milling Machine



THE "PRECISION" PRODUCES GOOD WORK

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF CLEVELAND, O., U.S.A.

wood alcohol, cleaning and dyeing works and chemical trades.

Warner & Swasey Co., Cleveland, Ohio. Catalogues of universal hollow-hexagon turret lathes. These catalogues illustrate the hollow-hexagon turret lathe equipped for bar and chucking work and show the standard bar and chucking equipment. Various types and sizes of turret screw machines and turret lathes are illustrated and specifications for each are given.

New Departure Mfg. Co., Bristol, Conn. Loose-leaf sheets Nos. 79 FE to 82 FE, inclusive, describing various installations of ball bearings, among which are ball bearings in Jordan pulp mill, vertical grindstone shaft bearing mounting, ball bearings for gear-driven through shaft, ball bearings for bevel gear shafts and ball bearings for worm-gear-driven elevator cable winding drum.

Heald Machine Co., 20 New Bond St., Worcester, Mass. Catalogue of magnetic chucks, revised and brought up to date. The catalogue treats of magnetic chucks and their application, design and construction of the Heald magnetic chuck, rotary type magnetic chucks, rectangular or straight type magnetic chucks, special types, and demagnetizing switch, demagnetizer and generator.

Cincinnati Lubricant Pump Co., 126 Opera Place, Cincinnati, Ohio. Booklet entitled "Scientific Lubrication of Cutting Tools," treating of the history of cutting tool lubrication, functions of lubricants, volume of coolant necessary, water solutions as coolants, applications of coolants, and means of delivering coolants. This booklet also contains a description of the "Fulflo" centrifugal lubricant pump.

Pennsylvania Railroad, Philadelphia, Pa. Poster issued for the purpose of warning people against crossing the tracks or otherwise trespassing on railroad property. The new "Stop" poster will be displayed at places where the general public is accustomed to take short-cuts across the tracks or to use the railroad right-of-way as a highway. It will also be placed on all bulletin boards in the stations and waiting rooms of the Pennsylvania Railroad system.

Armstrong Cork Co., Pittsburg, Pa. Pamphlet descriptive of "Nonpareil" corkboard insulation for cold storage warehouses, ice plants, creameries, packing plants, fur vaults, refrigerators, etc. Pamphlet entitled "Fifteen Years on Brine Lines," illustrating the condition of "Nonpareil" cork covering after fifteen years of service on a 1½-inch brine line, which shows graphically the adaptability of cork covering for this work. Copies of these pamphlets will be sent free upon request.

Midvale Steel Co., Philadelphia, Pa. Catalogue 33 of alloy and tool steel, containing information on the properties, treatment, etc. A table is included which gives the temperatures to which steel should be heated to temper it for different kinds of service. A list of the brands of Midvale carbon tool steels and high-speed steels, and the uses for which they are suited, is also given. Sections are devoted to stellite, alloy steels, steels for hot working, etc. Section 5 contains many useful tables and gives critical temperature and physical property curves of Midvale steels.

Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio. Catalogue 70, entitled "Hydraulic Presses and Pumps." This catalogue contains 84 pages, 8 by 10 inches, describing and illustrating the line of hydraulic machinery built by the company. The types of machinery especially intended for export and use in foreign countries are described. The catalogue gives considerable general data, and in addition illustrates metal-working presses, veneer presses, baling presses, abrasive wheel presses, leather presses, butchers' and packers' presses, oil presses, cider, wine and grape-juice presses, hot plate presses, hydraulic valves and hydraulic pumps.

Pennsylvania Railroad, Philadelphia, Pa. Booklet entitled "Pennsylvania Railroad System—Historical and Descriptive, with Annotated Map." This booklet has been issued to preserve in permanent form the most interesting and picturesque incidents connected with the settlement and subsequent development of the region traversed by the Pennsylvania Railroad system. Another purpose is to set forth the present character of the various portions of the territory with reference to industry, mining, agriculture and commerce. A brief description is given of all the cities and of the more important towns, with the business advantages of each. The book is profusely illustrated, and is accompanied by a large folding map.

Wilson Welder & Metals Co., Inc., New York City. Catalogue 1, treating of electric welding. The book describes the Wilson system of welding, its development, scope and points of superiority. Details are given of the specially prepared metal electrodes which are not adversely affected by the heat of the arc. The equipment is shown by numerous half-tone and line engravings, and specifications for the motor-generator sets, etc., are given. The book concludes with results obtained from the use of the Wilson system, showing some interesting jobs of welding; physical tests of electrically welded joints; and tables of weights and measures, wiring table, specific gravity and fusing point of metals, high temperatures judged by colors and various temperatures of furnaces.

TRADE NOTES

Universal Machine Works, makers of toolpost turrets, have moved from 211 W. 59th St., New York City, to 626 Driggs Ave., Brooklyn, N. Y.

Himoff Machine Co., manufacturer of lathes, screw machines and gear hobbing machines, has moved from 138 Mott St., New York City, to more spacious quarters at 45 Mills St., Astoria, L. I.

Rockford Machine Tool Co., Rockford, Ill., manufacturer of shapers, planers, drilling machines and vertical milling machines, has completed a large addition to its plant, including a new office building.

Burdett Oxygen Co., 1401 Jackson Blvd., Chicago, Ill., has recently completed the erection of a new plant at 40th St. and Allegheny Valley Railroad, Pittsburg, Pa., and is now in a position to furnish oxygen to users in the Pittsburg territory.

Ott Grinder Co., 32 N. Clinton St., Indianapolis, Ind., has been incorporated with a capital of $50,000, and is now equipping a plant for the manufacture of its No. 2 universal grinding machine for the present, and for smaller and larger sizes later on.

H. E. Harris Engineering Co., Bridgeport, Conn., is planning extensive additions to its plant, with the purpose of tripling the present capacity. The company has taken a five-year lease of the property at 1041-1055 Broad St. and 116-118 John St., Bridgeport, Conn., where the offices and factory are now located.

T. A. Willson & Co., Inc., 3rd and Washington Sts., Reading, Pa., has leased a prominent spot at the National Advertisers Permanent Exposition on Garden Pier, Atlantic City, N. J., for the educational purpose of instructing the general public in the various uses of Willson goggles and safety glasses. A demonstrator will be constantly in charge.

Mansfield Lock Washer Co., Mansfield, Ohio, was recently organized for the manufacture of lock washers. The officers are W. H. Davey, president; Charles F. Ackerman, vice-president; A. E. Witter, secretary and treasurer; and F. E. Kessel, general superintendent. Mr. Kessel is the inventor of the machines that will be used in the production of the lock washers.

Link-Belt Co., Chicago, Ill., has made extensive additions to its Belmont works to keep pace with the demand for Link belts for conveying, elevating and power transmission purposes. The fifth furnace of the Belmont plant of the company at Indianapolis was blown in the middle of December, adding materially to the capacity of the plant for producing malleable link-belts.

Black & Decker Mfg. Co., Calvert and Lombard Sts., Baltimore, Md., has purchased a ten-acre tract on the outskirts of Baltimore with railway facilities, on which a factory will be erected for the manufacture of the "Lectroflater" (an electrically-driven air pump for garages) and the B & D electric drill. The business of the company in these lines is growing so rapidly that a new plant is necessary to take care of it.

Hodge Engineering & Contracting Co., Inc., Equitable Bldg., New York City, have been organized to act as expert advisers in connection with the manufacture of small arms ammunition and primers of all types. Theodore DeW. Moore, recently associated with the company, brings to it knowledge of the fire-arms and ammunition business gained by some thirty years' experience in its commercial and manufacturing branches.

Western Tool & Mfg. Co., Springfield, Ohio, manufacturer of "Champion" tool-holders, vises, shop furniture, hacksaws and foundry equipment, has made two large additions to its plant to take care of its rapidly increasing business. One of the additions is to enlarge the shop furniture department, which has grown very rapidly. The company has recently purchased the patents for the Victor universal vise, and is now ready to fill orders.

American International Corporation, 120 Broadway, New York City. Preliminary report of the president to the stockholders. The American International Corporation in February, 1916, acquired the entire capital stock of the Allied Machinery Co. of America, which conducts an export business in machine tools. It also has extensive business in other lines in foreign countries, including contracting, trading, rosin and turpentine manufacture, shipping, etc.

W. H. Nicholson & Co., 112 Oregon St., Wilkesbarre, Pa., have completed the new addition to their plant which has been under construction for some time. The new machinery required is being installed. The addition, which will increase the floor space about 100 per cent, was needed to meet the increasing demand for the Nicholson expanding mandrels, compression shaft couplings, "Wyoming" steam specialties, as well as gage, jig and fixture work.

Stocker-Rumely-Wachs Co. is the successor to the H. A. Stocker Machinery Co. and the Rumely-Wachs Machinery Co., and will be located at 117-121 N. Jefferson St., Chicago, Ill. The officers are H. A. Stocker, president; W. N. Rumely, vice-president; H. J. Reeve, treasurer; O. A. Wachs, assistant treasurer; and Edward H. Wachs, Jr., secretary. The capital stock of the new organization will be $225,000. The selling force of both concerns will be retained.

Grand Rapids Grinding Machine Co., Grand Rapids, Mich., is a new concern recently incorporated to manufacture a line of grinding machinery. The president and treasurer is S. Owen Livingston, formerly secretary and general manager of the Wilmarth & Morman Co. of Grand Rapids, and the vice-president and superintendent is J. DeKoning, formerly superintendent of the Wilmarth & Morman Co.'s shop. The secretary is Charles F. Hext, who will not at present actively participate in the business management.

Cosmic Chemical Co., Ltd., has recently opened offices at 74 Cortlandt St., New York City. This firm manufactures cutting oils, drawing compounds, greases and automobile soaps. It has developed, after years of experimenting, an artificial lard oil which is claimed to be equal to animal lard oil. A refinery consisting of six large buildings has recently been completed at Trenton, N. J., to meet the increasing demand for the company's product. The company is a close corporation and is fully equipped to meet any demands. Marvin F. Wood is the sales manager.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., announces an extension of its present bonus system to include salaried and office employes on hourly rates, by which they will receive a bonus of 8 per cent of their salary each month, providing their total excusable time absent and late during the month does not exceed six hours incurred on not over three occasions. An additional 4 per cent will be given each month to the employe who has not lost any time from work during the month through absence or tardiness, thus enabling those affected to obtain an increase in earnings of 12 per cent for 100 per cent attendance. Several thousand employes in the Pittsburg district will be benefited by the granting of the bonus.

Landis Tool Co., Waynesboro, Pa., has erected a new factory for the manufacture of its floor-type boring, milling, drilling and tapping machine. The building is of brick, concrete and steel, and of fireproof construction throughout. It is 105 feet wide, 176 feet long, and has a concrete floor, concrete tile roof, steel sash and steel partitions throughout. The building is divided into three sections. The main bay is 60 feet wide, 136 feet long, and is spanned by a ten-ton electrically operated crane. Parallel to the main bay is the machine shop, which is 45 feet wide, 176 feet long, and of sawtooth roof construction. The northwest section of the building is two stories high, the office and drawing-room being located on the top floor, and the wash-room and locker-room on the first floor.

Thomson Spot Welder Co., Cincinnati, Ohio, which has been recently formed under the Massachusetts laws, has acquired all the patents for the process of spot-welding and spot-welding machines formerly held by the Thomson Electric Welding Co. and the Universal Electric Welding Co. It has also acquired all the physical assets and all the spot-welding patents, etc., of the Toledo Electric Welder Co., Cincinnati, Ohio, which is being liquidated after having been forced into litigation to admit the validity of the Harmatta patent. The butt-welding machine business formerly conducted by this company has been taken over by the Thomson Electric Welding Co., Lynn, Mass., who will manufacture these machines in the future and look after the needs of the Toledo Electric Welder Co.'s customers.

United Hammer Co., 141 Milk St., Boston, Mass., has issued an announcement in regard to the Fairbanks hammers. These have been manufactured since 1890; first, by the Dupont Mfg. Co. of St. Johnsbury, Vt., who marketed them under the name "Dupont" hammers. In 1902 the business was taken over by E. & T. Fairbanks & Co., St. Johnsbury, who have been manufacturing them since, giving the machines the name "Fairbanks" hammers, which title will be continued by the United Hammer Co. During the time the hammers were manufactured by E. & T. Fairbanks & Co. they were sold by their selling agent—the Fairbanks Co. of New York City, and branches in the East; by Fairbanks, Morse & Co., Chicago, and branches in the West; and by the Canadian Fairbanks Co. in Montreal, and by its branches in Canada. They were also sold in Europe by branches of the Fairbanks Co. About 1400 installations have been made.

Precision Die Casting Co., Inc., Syracuse, N. Y., was recently organized to take over the business of the Van Wagner Die Casting Corporation and the Precision Die Casting Co., the two concerns being merged and capitalized at $315,000. The officers are T. G. Meachem, president; J. W. Knapp, vice-president and general manager; H. S. Tenney, treasurer; and E. J. Quintal, secretary. T. G. Meachem, the president, is widely known as the active head of the New Process Gear Corporation of Syracuse. This company continued making gears in a small way for years until Mr. Meachem took hold of the business, and its present size and standing is a monument to his energy and business ability. No changes will be made in the personnel of the Precision Die Casting Co.'s plant or organization, but such alterations and extensions will be made as are necessary to secure improved quality and better service in the production of die-castings.

Doehler Die-Casting Co., Court and Ninth Sts., Brooklyn, N. Y., realizing the increasing cost of living, has announced that a wage dividend will be paid to its employes beginning January 1, 1917. This dividend will amount to 10 per cent per annum to all employes, based on the wages actually received, including piece-work and overtime. The wage dividend will be declared quarterly, the same as the stock dividend. It will be subject to the following conditions: (1) An employe must be in the employ of the Doehler Die-Casting Co. without interruption for a full year before he can participate in the wage dividend; his dividend will be calculated from the date of completing the first year's employment to the date of declaration of the dividend. (2) The dividend will be paid in full to all employes who have been in the employ of the company for a full period of three years or more. (3) Two-thirds of the dividend will be paid to all employes who have been in the employ of the company for a full period of two years and less than three years. (4) One-third of the dividend will be paid to all employes who have been in the employ of the company for a full period of one year and less than two. It is further announced that beginning January 1, 1917, all employes who have been working on the basis of fifty hours per week will be put on a basis of forty-eight hours per week at the same pay. The company employs 1200 men and has a weekly pay-roll of approximately $25,000.